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NORTH OF ENGLAND INSTITUTE OF MINING
AND MECHANICAL ENGINEERS.

TRANSACTIONS.

VOL. XXIV.

1874-75.

NEWCASTLE-UPON-TYNE : A. REID, PRINTING COURT BUILDINGS, AKENSIDE HILL.

1875.

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NEWCASTLE-UPON-TYNE:
ANDREW REID, PRINTING COURT BUILDINGS, AKENSIDE HILL.

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Report.

THE Council, in presenting their annual Report to the members, have again to announce the continued prosperity of the Institute. The total number on the register, after deducting losses by deaths, resignations, &c., is 850, being a net increase of 71 over the preceding year—considerably above the average, and within a very few, of the largest number that ever joined in one year.

It is with great satisfaction that the Council regards the continued success of the College of Physical Science, as it proves that the efforts made for so many years by the Institute rested upon a well-grounded assurance of the necessity of such an establishment in Newcastle; indeed, the success of the College has been so great, that the last Report presented to the Governors states that the principal cause of anxiety now is, how to obtain suitable premises for its permanent accommodation, and recommends that immediate steps should be taken to provide funds for the erection of the various laboratories, class-rooms, museums, &c., required for successfully carrying on so large and important an undertaking.

The Institute having from the first taken an active part in the promotion of the College, and so many of its members having liberally supported its endowment, has led the Council carefully to watch its progress; and they are fully of opinion that the time has arrived for extending its operations and providing for its permanency, and would earnestly recommend the members of the Institute, both as individuals and as a body, to assist in finishing the work so happily commenced.

The Council considers that the Institute has reason to congratulate itself on the quality of the papers read before its members since the last annual meeting. Mr. Forster Brown's paper on the South Wales Coal-field, and the carefully prepared map that accompanied it, will prove of great use to all gentlemen interested in mining operations; also Mr. Simpson's paper on the Coal-fields of Russia, Messrs. Daglish and Howse's paper on the Lincolnshire Ironstone Beds, and Mr. Bassett's on the Diamond Boring Machine, are deserving of notice as being replete with valuable information. The present volume will also contain two very

interesting and valuable papers on the Coal-field and Industries of Cape Breton; the first, entitled the "Submarine Coal-field of Cape Breton," by Mr. E. Gilpin, and the second on the "Sydney Coal-field of Cape Breton," by Mr. W. Rontledge, give a complete description of the various formations, seams, and collieries of this important district.

It is with deep regret that the Council has to record the loss of more than the average number of members by death during the past year. Mr. Thomas Emerson Forster, one of the original founders and a past president of the Institute, born at Allenheads in 1802, died on the 7th day of March, 1875. This gentleman was intimately connected with the mining interests of Great Britain, and was everywhere known by his ability, indefatigable industry, shrewdness, sagacity, and large-hearted generosity. He was an ardent supporter of the Institute, and a kind and benevolent friend; and his loss has been felt by all who had the pleasure of his acquaintance. A memoir of his life is in course of preparation, and will be read before an early meeting of the Institute.

Mr. Joseph Love, many years one of our members, was born in 1796 and died 21st February last. He was long and intimately connected with the coal industries of the North. From 1812 to 1815 he worked in the pit, at West Moor, where Nicholas Wood and George Stephenson were then employed. Like these remarkable men, he employed the whole of his leisure hours in self-improvement and study. He afterwards worked for a short time in the pits at Percy Main and Jarrow; but in 1821 he left pit work and turned his attention to commercial pursuits. Beginning in a humble way, he, by his indomitable perseverance, soon met with considerable success. His ventures gradually took a wider scope, and one of his earliest important speculations was the building of some workmen's houses, by which he netted what was then to him a considerable sum. Shortly after this he unfortunately suffered a heavy pecuniary loss by the failure of one of the North of England Banks; but, undeterred, he laboured with fresh activity, and soon reimbursed himself. He became connected with the Messrs. J. & J. Straker & Co., and with them purchased the royalty of the Brancepeth coal. This coal promised to be almost useless for ordinary purposes, but Mr. Love conceived the happy idea of making it into coke, which proved of such excellent quality that it soon obtained a prominent place in the market, which it still retains. After this, success attended all his enterprises, which enabled him to amass considerable sums. He was most liberal and generous both in his commercial and private connections, and won the esteem and affection of all who came in contact with him. He was especially earnest in his endeavours to

spread religious instruction, and munificently assisted all sects of Christianity in their endeavours to promote public worship.

The Council, in conclusion, cannot refrain from alluding to the very great success of the meeting at Cardiff, and the very gratifying reception the members met with during their visit. Reverting to this visit, and to the other very successful ones held in Manchester, Birmingham, and Glasgow, it would seem that these meetings, if not made too often, greatly add to the success of the Institute, increase its members, add interest to its transactions, and generally extend its scope and usefulness; and the Council would recommend that a meeting should be held in the autumn of next year, at a place to be fixed at as early a date as possible, and that, seeing the importance of the vast mining and engineering operations now going on abroad, the desirability of having such meeting either in France or Germany should be carefully discussed.

Finance Report.

THE Finance Committee have to report that the income for the past year shows an increase, as compared with the preceding year, of £88 17s. 6d.; the receipts from all sources in 1873-74 being £1,944 17s. 8d., and this year £2,033 15s. 2d. The expenditure has been £231 4s. 2d. less than the income.

In accordance with the recommendation of the Council, agreed to at the general meeting held last August, the sum of £620 has been invested in shares of the Institute and Coal Trade Chambers Company, Limited, and the Committee recommend that from time to time, as occasion offers, the surplus funds of the Institute be invested in the same manner.

The Institute now holds 133 of these shares, representing £2,660.

JOHN DAGLISH.

ADVERTISEMENT.

THE Institute is not, as a body, responsible for the facts and opinions advanced in the Papers read, and in the Abstracts of the Conversations which occurred at the Meetings during the Session.

DR.

THE TREASURER IN ACCOUNT

						£	s.	d.
To 703 Old Members, as per List, 1874-75 ...	...	...	...	...	...	1,476	6	0
To 76 New Members, as per List, 1874-75 ..	...	...	...	...	...	159	12	0
To 76 Old Students, do. do. ...	...	...	...	...	...	79	16	0
To 5 Do. paid as Members ...	...	...	...	...	...	5	5	0
To 27 New Students, as per List, 1874-75...	...	...	...	...	...	28	7	0
To 1 Life Member's Subscription ...	...	...	...	...	...	20	0	0
To 14 Subscribing Collieries...	...	...	...	...	...	71	8	0
						<hr/>		
						1,840	14	0
To Arrears as per last Balance Sheet ...	...	...	...	...	199	10	0	
<i>Deduct—</i>								
Irrecoverable Arrears not inserted in 1874-75 List								
(Dead, Resigned, &c.) ...	...	...	...	...	...	88	4	0
						<hr/>		
Actual Arrears to Collect, 1874-75 ...	...	...				111	6	0
							<hr/>	
							£1,952	0 0
							<hr/>	

WITH SUBSCRIPTIONS, 1874-75.

CR.

							PAID.			UNPAID.		
							£	s.	d.	£	s.	d.
By	639	Old Members paid	...	...	...	...	1,341	18	0			
By	5	Do. dead	...	...	...	...				10	10	0
By	3	Do. resigned	...	...	...	...				6	6	0
By	56	Do. unpaid	...	...	...	...				117	12	0
<hr/>												
703												
<hr/>												
By	68	New Members paid	...	...	...	...	142	16	0			
By	7	Do. unpaid	...	...	...	...				14	14	0
By	1	Do. paid as Life Member	...	...	...	...				2	2	0
<hr/>												
76												
<hr/>												
By	70	Old Students paid	...	...	...	...	73	10	0			
By	1	Do. resigned	...	...	...	...				1	1	0
By	5	Do. unpaid	...	...	...	...				5	5	0
<hr/>												
76												
<hr/>												
By	5	Old Students paid as Members	...	...	...	...	5	5	0			
<hr/>												
By	26	New Students paid	...	...	...	...	27	6	0			
By	1	Do. unpaid	...	...	...	...				1	1	0
<hr/>												
27												
<hr/>												
By	1	Life Member	...	...	...	...	20	0	0			
By	14	Subscribing Collieries	...	...	...	...	71	8	0			
							<hr/>			<hr/>		
							1,682			158		
							3			11		
							0			0		
By	Members' Arrears					...	38	17	0	69	6	0
By	Students' Arrears					...	1	1	0	2	2	0
							<hr/>			<hr/>		
							1,722			229		
							1			19		
							0			0		
							<hr/>			<hr/>		
							1,722			1		
										0		

Audited and Certified,

BENSON, ELAND, & CO.,

PUBLIC ACCOUNTANTS.

Newcastle-on-Tyne, August 6, 1875.

£1,952 0 0

THE TREASURER IN ACCOUNT WITH NORTH OF ENGLAND

DR.

For the Year ending

	£	s.	d.	£	s.	d.
To Balance at Bankers				927	1	1
„ Balance in hands of Secretary				79	2	10
„ Balance in hands of Liquidators of District Bank ...				12	7	3
„ Bequest of the late R. Stephenson, Esq., invested in Shares of the Institute and Coal Trade Chambers Co., Limited				2,000	0	0
				3,018	11	2
„ Dividend of 6 per cent. on the above Shares ..	159	12	0			
Less paid to previous holders	19	0	6			
				140	11	6
„ Rent of College Class Rooms, less Borough Rate ...				48	17	4
„ Subscriptions for 1874-75, from 639 Old Members ...	1,341	18	0			
Ditto ditto 68 New Members ...	142	16	0			
Ditto ditto 70 Old Students ...	73	10	0			
Ditto ditto 5 Do. paid as members ...	5	5	0			
Ditto ditto 26 New Students ...	27	6	0			
Ditto ditto 1 Life Member ...	20	0	0			
„ 14 Subscribing Collieries, viz. :—						
East Holywell	2	2	0			
Haswell	4	4	0			
Hetton	10	10	0			
Lambton	2	2	0			
North Hetton	10	10	0			
Rainton	6	6	0			
Ryhope	10	10	0			
Seghill	4	4	0			
South Hetton and Murton	8	8	0			
Stella	2	2	0			
Throckley	2	2	0			
Wearmouth	4	4	0			
Whitworth	2	2	0			
Ashington	2	2	0			
				71	8	0
„ Members' Arrears	38	17	0			
„ Students' Do.	1	1	0			
				1,722	1	0
„ Sale of Publications per A. Reid	135	14	0			
Less 10 per cent. Commission	13	8	8			
				122	5	4
				£5,052	6	4

INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

August, 1875.

CR.

	£	s.	d.	£	s.	d.
By paid A. Reid, Publishing Account	716	13	7			
Ditto Covers for Parts, and Stitching ...	48	13	6			
Ditto Binding and Sewing Volumes	57	7	9			
Ditto Postage	46	1	8			
Ditto Stationery and Circulars	171	7	10			
Ditto Library	10	19	0			
	<hr/>			1,051	3	4
„ Secretary's Incidental Expenses and Postage ...				102	1	6
„ Sundry Accounts				13	11	6
„ Travelling Expenses and Expenses of Cardiff Meeting				64	14	2
„ Secretary's Salary				250	0	0
„ Assistant's do.				62	10	0
„ Reporter				13	13	0
„ Purchase of 31 Shares in Institute and Coal Trade Chambers Company, Limited, @ £20				620	0	0
„ Payments on account of Furnishing				12	17	9
„ Rent... ..				72	11	0
„ Rates and Taxes				14	17	10
„ Fire Insurance				3	12	6
„ Coals and Gas				19	3	0
„ Subscription to Natural History Society				20	0	0
„ Prizes for Papers				14	2	6
„ Library				22	8	5
„ Law Charges				65	4	6
„ Bequest of R. Stephenson, Esq., invested in Shares of Institute and Coal Trade Chambers Co., Limited ...				2,000	0	0
„ Balance in hands of Liquidators of District Bank ...				12	7	3
„ Balance at Bankers				569	7	5
„ Balance in hands of Secretary				48	0	8

Audited and Certified,

BENSON, ELAND, & CO.,

PUBLIC ACCOUNTANTS.

Newcastle-on-Tyne, August 6, 1875.

£5,052 6 4

Dr. GENERAL STATEMENT, JULY, 1875. Cr.

Liabilities.			Assets.		
£	s.	d.	£	s.	d.
Liabilities	Balance of Account at Bankers	...	569 7 5
Capital	Do. in hands of Liquidators of District Bank	...	12 7 3
	Do. in hands of Secretary	...	48 0 8
			133 £20 Shares in the Institute and Coal Trade Cham-		
			bers Company, Limited	...	2,660 0 0
			Arrears of Subscription	...	229 19 0
			Value of 281 bound Vols. of Transactions	£147 10 6	
			Do. 2,307 sewn Copies do.	1,088 3 0	
			Do. sundry Sheets and Plates belonging		
			to Vol. 24, unfinished at this date	438 13 0	
			Do. 50 Copies of Mr. T. Forster Brown's		
			Map	...	12 10 0
					1,686 16 6
					£5,206 10 10

Audited and certified,
BENSON, ELAND, & CO.,
PUBLIC ACCOUNTANTS.

Newcastle-on-Tyne, August 6, 1875.

Patrons.

His Grace the DUKE OF NORTHUMBERLAND.

His Grace the DUKE OF CLEVELAND.

The Most Noble the MARQUESS OF LONDONDERRY.

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WENTWORTH B. BEAUMONT, Esq., M.P.

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		ELECTED.	
		ORDY.	HON.
WILLIAM ALEXANDER, Esq., Inspector of Mines, Glasgow	...		1863
* JAMES P. BAKER, Esq., Inspector of Mines, Wolverhampton	...	1853	1866
LIONEL BROUGH, Esq., Inspector of Mines, Clifton, Bristol	...		1855
JOSEPH DICKINSON, Esq., Inspector of Mines, Manchester	...		1853
THOMAS EVANS, Esq., Inspector of Mines, Pen-y-Bryn, Duffield Road, Derby	... ..		1855
* RALPH MOORE, Esq., Inspector of Mines, Glasgow	...		1866
* THOMAS E. WALES, Esq., Inspector of Mines, Swansea	...	1855	1866
* FRANK N. WARDELL, Esq., Inspector of Mines, Wath-on-Deerne, near Rotherham	... ..	1864	1868
* JAMES WILLIS, Esq., Inspector of Mines, 73, Westmorland Road, Newcastle	... ..	1857	1871
THOMAS WYNNE, Esq., Inspector of Mines, Manor House, Gnosal, Stafford	... ..		1853
R. P. PHILIPSON, Esq., Newcastle-upon-Tyne	... ..		1874
WARINGTON W. SMYTH, Esq., 28, Jermyn Street, London	...		1869
THE VERY REV. DR. LAKE, Dean of Durham	... ..		1872
* PROF. A. FREIRE-MAIRECO, M.A., College of Physical Science, Newcastle-upon-Tyne	... ..		1872
„ A. S. HERSCHEL, B.A., F.R.A.S., do.	do. ...		1872
* „ W. S. ALDIS, M.A., do.	do. ...		1872
* DR. DAVID PAGE, LL.D., do.	do. ...		1872
M. DE BOUREUILLE, Commandeur de la Légion d'Honneur, Conseiller d'état, Inspecteur General des Mines, Paris	...		1853
DR. H. VON DECHEN, Berghauptmann, Ritter, etc., Bon am Rhine, Prussia		1853
M. THEOPHILE GUIBAL, School of Mines, Mons, Belgium	...		1870

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E. B. COXE, Esq., Drifton, Jeddo, P.O., Luzerne Co., Penns., U.S.	1873	1874
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R. CLIFFORD SMITH, Esq., Parkfield, Swinton, Manchester	...	1874 1874

* Honorary Members during term of office only.

OFFICERS, 1875-76.

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JOHN DAGLISH, Esq., Tynemouth.

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D. P. MORISON, Esq., Collingwood Street, Newcastle-on-Tyne.

JAMES NELSON, Esq., King's House Engine Works, Sunderland.

R. S. NEWALL, Esq., Ferndene, Gateshead.

W. A. POTTER, Esq., Cramlington House, Northumberland.

J. A. RAMSAY, Esq., Washington Colliery, Co. Durham.

J. T. RAMSAY, Esq., Walbottle Hall, Blaydon-on-Tyne.

J. B. SIMPSON, Esq., Hedgefield House, Blaydon-on-Tyne.

JAMES WILLIS, Esq., 73, Westmorland Road, Newcastle-on-Tyne.

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		Jesmond, Newcastle-on-Tyne.		
		E. F. BOYD, Esq., Moor House, Fence Houses.		
		SIR GEO. ELLIOT, BART., M.P., Houghton Hall,		Retiring Vice-Presidents.
		Fence Houses.		
		G. B. FORSTER, Esq., M.A., Backworth House,		
		near Newcastle-on-Tyne.		
		JOHN MARLEY, Esq., Mining Offices, Darlington.		
		A. L. STEAVENSON, Esq., Durham.		

Secretary and Treasurer.

THEO. WOOD BUNNING, Neville Hall, Newcastle-on-Tyne.

List of Members.

AUGUST, 1875.

				ELECTED.
1	Ackroyd, Thomas, Berkenshaw, Leeds ...	...	...	Mar. 7, 1867
2	Adams, G. F., Guildhall Chambers, Cardiff ...	...	...	Dec. 6, 1873
3	Adams, W., Cardiff ...	...	...	1854
4	Ainslie, Aymer, Hall Garth, Carnforth ...	...	...	Aug. 7, 1869
5	Aitkin, Henry, Falkirk, N.B. ...	...	...	Mar. 2, 1865
6	Allison, T., Belmont Mines, Guisbro' ...	...	...	Feb. 1, 1868
7	Anderson, C. W., Kirk Hammerton Hall, York ...	...	...	Aug. 21, 1852
8	Anderson, William, Rainton Colliery, Fence Houses ...	...	...	Aug. 21, 1852
9	Andrews, Hugh, Eastfield Hall, Bilton, Northumberland	...	...	Oct. 5, 1872
10	Appleby, C. E., Whitehall Club, Parliament Street, London, S.W. ...	...	...	Aug. 1, 1861
11	Archbold, James, Engineer, Ryton-on-Tyne ...	...	...	Feb. 1, 1873
12	Archer, T., Dunston Engine Works, Gateshead ...	...	...	July 2, 1872
13	Arkless, John, Tantoby, Burnopfield ...	...	...	Nov. 7, 1868
14	ARMSTRONG, Sir W. G., C.B., LL.D., F.R.S., Jesmond, Newcastle-upon-Tyne, ...	...	...	May 3, 1866
15	ARMSTRONG, WILLIAM, Senior, Pelaw House, Chester-le- Street ...	...	...	Aug. 21, 1852
16	ARMSTRONG, W., jun., Wingate, Co. Durham (<i>Member of Council</i>)	...	...	April 7, 1867
17	Armstrong, W. L., 5, Hawthorn Terrace, Newcastle ...	...	...	Mar. 3, 1864
18	Ashwell, H., Anchor Colliery, Longton, No. Staffordshire	...	...	Mar. 6, 1862
19	Asquith, T. W., Seaton Delaval Colliery, Northumberland	...	...	Feb. 2, 1867
20	Atkinson, W. N., Chilton Moor, Fence Houses ...	...	...	June 6, 1868
21	Aubrey, R. C., Astley House, Woodlesford, near Leeds	...	...	Feb. 5, 1870
22	Austin, C. D., 40, Mosley Street, Newcastle-on-Tyne ...	...	...	July 2, 1872
23	Aynsley, Wm., West Stanley Colliery, Chester-le-Street	...	...	Mar. 3, 1873
24	Bachke, A. S., Ytterven Mines, near Drontheim, Norway	...	...	Mar. 5, 1870
25	Bagnall, T., jun., Milton Ernest Hall, Bedford ...	...	...	Mar. 6, 1862
26	Bailes, John, Wingate Colliery, Ferryhill ...	...	...	Sept. 5, 1868
27	Bailes, T., jun., 41, Lovaine Place, Newcastle-on-Tyne	...	...	Oct. 7, 1858

ELECTED.

28	Bagley, Chas. John, Tees Bridge Iron Co., Stockton	...	June	5, 1875
29	Bailey, C., Heworth Colliery, near Newcastle	...	Nov.	9, 1874
30	Bailey, G., St. John's Colliery, Wakefield	...	June	5, 1869
31	Bailey, Samuel, The Pleck, Walsall, Staffordshire	...	June	2, 1859
32	Bailey, W. W., Kilburn, near Derby	...	May	13, 1858
33	Bainbridge, E., Nunnery Colliery Offices, Sheffield	...	Dec.	3, 1863
34	Barclay, A., 54, St. Vincent Street, Glasgow	...	Dec.	6, 1866
35	Barkus, Wm., Tynemouth	...	Aug.	21, 1852
36	Barnes, R. J., Atherton Collieries, near Manchester	...	Sept.	13, 1873
37	Barnes, T., Seaton Delaval Office, Quay, Newcastle	...	Oct.	7, 1871
38	Bartholomew, C., Doncaster, Yorkshire	...	Aug.	5, 1853
39	Bassett, A., Tredegar Mineral Estate Office, Cardiff	...		1854
40	Bates, Matthew, Cyfarthfa Iron Works, Merthyr Tydvil	Feb.	1, 1868	
41	Bates, Matthew, Bews Hill, Blaydon-on-Tyne	...	Mar.	3, 1873
42	Bates, Thomas, Heddon, Wylam, Northumberland	...	Mar.	3, 1873
43	Bates, W. J., Bews Hill, Blaydon-on-Tyne	...	Mar.	3, 1873
44	Batey, John, Newbury Collieries, Coleford, Bath	...	Dec.	5, 1868
45	Beacher, E., Chapeltown, near Sheffield	...		1854
46	Beanlands, A., M.A., North Bailey, Durham	...	Mar.	7, 1867
47	Beaumont, James, M.E., Oughtbridge, near Sheffield	...	Nov.	9, 1874
48	BELL, I. LOWTHIAN, Washington, Washington Station, N.E. Railway	...	(VICE-PRESIDENT)	July 6, 1854
49	Bell, John, Normanby Mines, Middlesbro'-on-Tees	...	Oct.	1, 1857
50	Bell, J. T., Wolsingham, <i>via</i> Darlington	...	May	2, 1874
51	Bell, Thomas, Jesmond, Newcastle-upon-Tyne	...	Sept.	3, 1870
52	Bell, T., jun., (Messrs. Bell Brothers,) Middlesbro'	...	Mar.	7, 1867
53	Benson, J. G., Accountant, Newcastle	...	Nov.	9, 1874
54	Benson, T. W., 11, Newgate Street, Newcastle	...	Aug.	2, 1866
55	BERKLEY, C., Marley Hill Colliery, Gateshead		(Member of Council)	Aug. 21, 1852
56	BEWICK, T. J., M. Inst. C.E., F.G.S., Haydon Bridge, Northumberland	...	(VICE-PRESIDENT)	April 5, 1860
57	Bidder, B. P., Duffryn Collieries, Neath, Glamorganshire	May	2, 1867	
58	Bidder, S. P., 24, Great George Street, Westminster, London, S.W.	...	Dec.	4, 1869
59	Bigland, J., Bedford Lodge, Bishop Auckland	...	June	4, 1857
60	Binns, C., Claycross, Derbyshire	...	July	6, 1854
61	Biram, B., Peasely Cross Collieries, St. Helen's, Lan.	...		1856
62	Black, James, jun., Portobello Foundry, Sunderland	...	Sept.	2, 1871
63	Black, W., Hedworth Villa, South Shields	...	April	2, 1870

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|----|---|---------------------------------------|-----|--------------------------------|
| 64 | Blagburn, C., King Street, Quay, Newcastle | ... | ... | Sept. 2, 1871 |
| 65 | Blandford, Thomas, Corbridge, Northumberland | ... | ... | Feb. 14, 1874 |
| 66 | Bolam, H. G., Little Ingestre, Stafford | ... | ... | Mar. 6, 1875 |
| 67 | Bolckow, H. W. F., M.P., Middlesbro'-on-Tees | ... | ... | April 5, 1855 |
| 68 | Bolton, H. H., Newchurch Collieries, near Manchester | Dec. | ... | 5, 1868 |
| 69 | Boot, J. T., M.E., The Orchards, Hucknall, near
Mansfield | ... | ... | April 1, 1871 |
| 70 | Booth, R. L., South Tyne Colliery, Haltwhistle | ... | ... | 1864 |
| 71 | Borries, Theo., Lombard Street, Quay, Newcastle | ... | ... | April 11, 1874 |
| 72 | Bouch, W., Shildon Works, Darlington | ... | ... | June 4, 1870 |
| 73 | Bourne, Peter, 39, Rodney Street, Liverpool | ... | ... | 1854 |
| 74 | Bourne, S., West Cumberland Hematite Iron Works,
Workington | ... | ... | Aug. 21, 1852 |
| 75 | Boyd, E. F., Moor House, Fence Houses | (PAST PRESIDENT
Member of Council) | ... | Aug. 21, 1852 |
| 76 | Boyd, Wm., 74, Jesmond Road, Newcastle | ... | ... | Feb. 2, 1867 |
| 77 | Bradford, Geo., Newbottle Colliery, Fence Houses | ... | ... | Oct. 11, 1873 |
| 78 | Breckon, J. R., Park Place, Sunderland | .. | ... | Sept. 3, 1864 |
| 79 | Brettell, T., Mine Agent, Dudley, Worcestershire | ... | ... | Nov. 3, 1866 |
| 80 | Briart, A., Ingénieur en chef des Charbonnages de
Mariemont et de Bascoup, Mons | ... | ... | Sept. 2, 1871 |
| 81 | Brogden, James, Coldringham, Cardiff | ... | ... | 1861 |
| 82 | Brown, E., 79, Clayton Street, Newcastle | ... | ... | Mar. 7, 1874 |
| 83 | Brown, John, Littleworth, Hednesford, near Stafford | ... | ... | Oct. 5, 1854 |
| 84 | Brown, J. N., 56, Union Passage, New St., Birmingham | ... | ... | 1861 |
| 85 | Brown, Thos. Forster, Guildhall Chambers, Cardiff | ... | ... | 1861 |
| 86 | Browne, B. C., Assoc. M.I.C.E., North Ashfield House,
Newcastle-on-Tyne | ... | ... | Oct. 1, 1870 |
| 87 | Bruton, W., Whitwood, Methley Junction, and Street-
house Collieries, near Normanton | ... | ... | Feb. 6, 1869 |
| 88 | Bryham, William, Rosebridge, &c., Collieries, Wigan | Aug. | ... | 1, 1861 |
| 89 | Bryham, W., jun., Douglas Bank Collieries, Wigan | ... | ... | Aug. 3, 1865 |
| 90 | Bunn, R. T., Grey Street, Newcastle | ... | ... | Dec. 6, 1873 |
| 91 | BUNNING, THEO. WOOD, Neville Hall, Newcastle-on-
Tyne | ... | ... | (Secretary and Treasurer) 1864 |
| 92 | Burn, James, The Avenue, Sunderland | ... | ... | Aug. 2, 1866 |
| 93 | Burrows, James, Douglas Bank, Wigan, Lancashire | ... | ... | May 2, 1867 |
| 94 | Cabry, J., Blyth and Tyne Railway Offices, Newcastle | Sept. | ... | 4, 1869 |
| 95 | Caldwell, George, Moss Hall Colliery, near Wigan | ... | ... | Mar. 6, 1869 |

96	Campbell, James, Staveley Works, Chesterfield	...	Aug.	3, 1865
97	Carr, Matthew, Scotswood, Newcastle-on-Tyne	...	May	3, 1873
98	Carr, Wm. Cochran, South Benwell, Newcastle	...	Dec.	3, 1857
99	Carrington, T., jun., Kiveton Park Coll., near Sheffield	Aug.	1, 1861	
100	Catron, J., Tyne Main Colliery, Gateshead	...	Nov.	3, 1866
101	Chadborn, B. T., Pinxton Collieries, Alfreton, Derbyshire			1864
102	Chambers, A. M., Thorndcliffe Iron Works, nr. Sheffield	Mar.	6, 1869	
103	Chambers, H., Tinsley Collieries, Sheffield	...	Dec.	2, 1871
104	Chapman, M., Plashetts Colliery, Northumberland	...	Aug.	1, 1868
105	Charlton, E., Evenwood Colliery, Bishop Auckland	...	Sept.	5, 1868
106	Charlton, F., C.E., Moot Hall, Newcastle-on-Tyne	...	Sept.	2, 1871
107	Charlton, George, Washington Colliery, Co. Durham	...	Feb.	6, 1875
108	Checkley, Thomas, M.E., Lichfield Street, Walsall	...	Aug.	7, 1869
109	Cheesman, I., Throckley Colliery, Newcastle	...	Feb.	1, 1873
110	Childe, Rowland, Wakefield, Yorkshire	...	May	15, 1862
111	Clarbour, Fountain, 11, Mark Lane, Withy Grove, Manchester	...	Nov.	1, 1873
112	Clark, C. F., Garswood Coal & Iron Co., near Wigan	Aug.	2, 1866	
113	Clark, G., Ravenhead Colliery, St. Helen's, Lancashire,	Dec.	7, 1867	
114	Clark, G., jun., Monkwearmouth Engine Works, Sunderland	...	Dec.	6, 1873
115	Clark, N., South Tanfield, Chester-le-Street	...	June	6, 1868
116	Clark, R. P., 22, Windsor Terrace, Newcastle	...	Nov.	7, 1868
117	Clark, W., M.E., The Grange, Teversall, nr. Mansfield	April	7, 1866	
118	Clark, William, Victoria Engine Works, Gateshead	...	Dec.	7, 1867
119	Clarke, T., Ince Hall Collieries, Wigan	...	Mar.	2, 1872
120	Coates, C. N., Whitefield House, Acklington	...	May	3, 1866
121	Cochrane, B., Aldin Grange, Durham	...	Dec.	6, 1866
122	Cochrane, C., The Grange, Stourbridge	...	June	3, 1857
123	Cochrane, H., The Longlands, Middlesbro'-on-Tees	...	Mar.	4, 1871
124	COCHRANE, W., Oakfield House, Coxlodge, Northumberland	...	(VICE-PRESIDENT)	1859
125	Cockburn, G., 8, Summerhill Grove, Newcastle	...	Dec.	6, 1866
126	Cockburn, W., Upleatham Mines, Upleatham, Marske	Oct.	1, 1857	
127	Coke, R. G., Tapton Grove, Chesterfield, Derbyshire	May	5, 1859	
128	Cole, H. A. B., Willington Quay, Newcastle-on-Tyne	Mar.	3, 1873	
129	Cole, Richard, Walker Colliery, nr. Newcastle-on-Tyne	April	5, 1873	
130	Cole, Robert E., Willington Quay, Newcastle-on-Tyne	Nov.	2, 1872	
131	Cole, W. R., Broomfield, Jesmond, Newcastle	...	Oct.	1, 1857
132	Collis, W. B., High House, Stourbridge, Worcestershire	June	6, 1861	

133	Cook, John, Wigan Coal and Iron Co., Wigan	...	Nov.	9,	1874
134	Cook, R. F., Esh Colliery, Durham	...	...	...	1860
135	Cooke, John, North Brancepeth Colliery, nr. Durham	Nov.	1,	1860	
136	Cooke, J., jun., Washington Iron Works, Gateshead...	May	8,	1869	
137	Cooksey, Joseph, West Bromwich, Staffordshire	...	Aug.	3,	1865
138	Cooper, P., Thornley Colliery Office, Ferryhill	...	Dec.	3,	1857
139	Cooper, R. E., C.E., 1, Westminster Chambers, Victoria Street, London, S.W.	...	...	Mar.	4, 1871
140	Cooper, T., Park Gate, Rotherham, Yorkshire	...	April	2,	1863
141	Cope, James, Port Vale, Longport, Staffordshire	...	Oct.	5,	1872
142	Corbett, V. W., Londonderry Offices, Seaham Harbour	Sept.	3,	1870	
143	Coulson, F., Shamrock House, Durham	...	...	Aug.	1, 1868
144	Coulson, W., Shamrock House, Durham	...	...	Oct.	1, 1852
145	Cowen, Joseph, M.P., Blaydon Burn, Newcastle	...	Oct.	5,	1854
146	Cowey, John, Wearmouth Colliery, Sunderland	...	Nov.	2,	1872
147	Cowlshaw, J., Thorncliffe, &c., Collieries, nr. Sheffield	Mar.	7,	1867	
148	Cox, John H., 10, St. George's Square, Sunderland	...	Feb.	6,	1875
149	Coxon, Henry, Quay, Newcastle-on-Tyne	...	...	Sept.	2, 1871
150	COXON, S. B., Usworth Colliery, Washington Station, Co. Durham	...	...	(Member of Council)	June 5, 1856
151	Craig, W. Y., Milton House, Alsager, Stoke-upon-Trent	Nov.	3,	1866	
152	Crawford, T., Littleton Colliery, near Durham	...	Aug.	21,	1852
153	Crawford, T., Bishop Middleham Colliery, nr. Ferryhill	Sept.	3,	1864	
154	Crawford, T., jun., Littleton Colliery, near Durham	Aug.	7,	1869	
155	Crawshay, E., Gateshead-on-Tyne	...	...	Dec.	4, 1869
156	Crawshay, G., Gateshead-on-Tyne	...	...	Dec.	4, 1869
157	Creighton, C. E., 10, Grey Street, Newcastle-on-Tyne	May	6,	1871	
158	Crofton, J. G., Castle Eden Colliery, Castle Eden, Co. Durham	...	...	Feb.	7, 1861
159	Crone, J. R., Stanhope, Darlington	...	...	Feb.	1, 1868
160	CRONE, S. C., Killingworth Colliery, Newcastle-upon- Tyne	...	...	(Member of Council)	1853
161	Cross, John, 78, Cross Street, Manchester	...	...	June	5, 1869
162	Croudace, C. J., Brayton Domain, &c., Colliery Office, Maryport	...	...	Nov.	2, 1872
163	Croudace, John, Baron House, Gilsland, N. E. Railway.	June	7,	1873	
164	Croudace, Thomas, Lambton Lodge, New South Wales				1862
165	Croudace, T. Daere, Clay Cross Colliery Offices, near Chesterfield	...	...	Mar.	7, 1867
166	Cuthbert, W., Beaufront Castle, Northumberland	...	Aug.	1,	1874

167	Daburon, Mons., Ingénieur aux Mines de Nœux, pas de Calais	...	...	...	...	May	1, 1875
168	DAGLISH, JOHN, F.G.S., Tynemouth (VICE-PRESIDENT)					Aug.	21, 1852
169	Daglish, W. S., Solicitor, Newcastle	...	...	...	...	July	2, 1872
170	Dakers, J., Old Durham Colliery, Durham	...	...	...	...	April	11, 1874
171	Dakers, W., Thornley Colliery, Ferry Hill	...	...	...	...	April	7, 1866
172	Dakers, W., jun., Birtley, Co. Durham	...	...	...	...	Oct.	3, 1874
173	Dale, David, West Lodge, Darlington	...	...	...	...	Feb.	5, 1870
174	D'Andrimont, T., Liège, Belgium	...	...	...	...	Sept.	3, 1870
175	Daniel, W., 37, Camp Road, Leeds	...	...	...	...	June	4, 1870
176	Darlington, John, 2, Coleman Street Buildings, Moor- gate Street, Great Swan Alley, London	...	...	...	...	April	1, 1865
177	Davey, Henry, C.E., Leeds	...	...	...	...	Oct.	11, 1873
178	Davidson, James, Newbattle Colliery, Dalkeith	...	...	...	...		1854
179	Davis, David, Coal Owner, Maesffynon, Aberdare	...	...	...	...	Nov.	9, 1874
180	Davison, A., Hastings Cottage, Dudley, Northumberland	...	...	...	...	Feb.	4, 1858
181	Day, W. H., Eversley Garth, So. Milford	...	...	...	...	Mar.	6, 1869
182	Dees, J., Whitehaven	...	...	...	...	Nov.	1, 1855
183	Dees, R. R., Solicitor, Newcastle-on-Tyne	...	...	...	...	Oct.	7, 1871
184	Defty, E., Wombwell Main Colliery, Barnsley	...	...	...	...	Dec.	5, 1874
185	Delgobe, Emile, 52, Wharnccliffe Street, Newcastle	...	...	...	...	Mar.	6, 1875
186	Dickinson, G. T., Wheelbirks, Northumberland	...	...	...	...	July	2, 1872
187	Dickinson, R., Coalowner, Shotley Bridge	...	...	...	...	Mar.	4, 1871
188	Dickinson, W. R., Priestfield Lodge, Lintz Green, Co. Durham	...	...	...	...	Aug.	7, 1862
189	Dinning, Joseph, Langley Smelt Mills, Northd.	...	...	...	...	April	5, 1873
190	Dixon, D. W., Brotton Mines, Saltburn-by-the-Sea	...	...	...	...	Nov.	2, 1872
191	Dixon, George, Lowther Street, Whitehaven	...	...	...	...	Dec.	3, 1857
192	Dixon, R., Wire Rope Manufacturer, Teams, Gateshead	...	...	...	...	June	5, 1875
193	Dobson, W., 16, North View, Heaton, Newcastle	...	...	...	...	Sept.	4, 1869
194	Dodd, B., Bearpark Colliery, near Durham	...	...	...	...	May	3, 1866
195	Dodds, J., M.P., Stockton-on-Tees	...	...	...	...	Mar.	7, 1874
196	Donaldson, P., Alipore, Calcutta	...	...	...	...	Nov.	1, 1873
197	Douglas, C. P., Consett Iron Works, Gateshead	...	...	...	...	Mar.	6, 1869
198	Douglas, T., Pease's West Collieries, Darlington	...	...	...	...	Aug.	21, 1852
199	Douthwaite, T., Merthyr Vale Colliery, Merthyr Tydvil	...	...	...	...	June	5, 1869
200	Dove, G., Portland Square, Carlisle	...	...	...	...	July	2, 1872
201	Dowdeswell, H., Butterknowle Colliery, <i>via</i> Darlington.	...	...	...	...	April	5, 1873
202	Dunlop, Colin, jun., Quarter Iron Works, Hamilton	...	...	...	...	Sept.	3, 1870
203	Dyson, George, Middlesborough	...	...	...	...	June	2, 1866

204	Dyson, O., Saltburn-by-the-Sea	...	...	...	Mar.	2, 1872
205	Easton, J., Nest House, Gateshead	...	...	...		1853
206	Eaton, J. R., 5, Saville Place, Newcastle-on-Tyne	...	Dec.	4,	1869	
207	Eaton, W. C., Saltburn-by-the-Sea	..	...	June	6,	1874
208	Eland, J. S., Accountant, Newcastle	...	...	Nov.	9,	1874
209	ELLIOT, SIR G., BART., M.P., Houghton Hall, Fence Houses	...	...	...	Aug.	21, 1852
		...	...	...	(<small>PAST PRESIDENT Member of Council</small>)	
210	Elliott, W., Tudhoe House, Durham	...	...	...		1854
211	Elliott, W. D., Pemberton Street, Hull	...	...	Oct.	11,	1873
212	Eltringham, W., West Shield Row, Chester-le-Street		Oct.	3,	1874	
213	Embleton, T. W., The Cedars, Methley, Leeds	...	Sept.	6,	1855	
214	Embleton, T. W., jun., The Cedars, Methley, Leeds...		Sept.	2,	1865	
215	Eminson, J. B., Londonderry Offices, Seaham Harbour		Mar.	2,	1872	
216	Everard, I. B., M.E., 6, Millstone Lane, Leicester	...	Mar.	6,	1869	
217	Farmer, A., Westbrook, Darlington	...	...	Mar.	2,	1872
218	Farrar, James, Old Foundry, Barnsley	...	...	July	2,	1872
219	Favell, Thomas M., 14, Saville Street, North Shields	...	April	5,	1873	
220	Fearn, John Wilmot, Chesterfield	...	...	Mar.	6,	1869
221	Fellows, J. H., Great Wyrley, nr. Walsall, Staffordshire		Dec.	5,	1874	
222	Fenwick, Barnabas, Team Colliery, Gateshead	...	Aug.	2,	1866	
223	Fenwick, George, Banker, Newcastle-on-Tyne	...	Sept.	2,	1871	
224	Fenwick, Thomas, East Pontop Colliery, by Lintz Green		April	5,	1873	
225	Fidler, E., Platt Lane Colliery, Wigan, Lancashire	...	Sept.	1,	1866	
226	Firth, S., M.A., 16, York Place, Leeds	...	...		1865	
227	Firth, William, Burley Woods, Leeds...	...	...	Nov.	7,	1863
228	Fisher, R. C., The Wern, Ystalyfera, Swansea	...	July	2,	1872	
229	Fletcher, G., Trimdon Colliery, Trimdon Grange	...	April	4,	1868	
230	Fletcher, Geo., Hamsteels Colliery, near Durham	...	Aug.	1,	1874	
231	Fletcher, H., Ladyshore Coll., Little Lever, Bolton, Lan.		Aug.	3,	1865	
232	Fletcher, I., M.P., Clifton Colliery, Workington	...	Nov.	7,	1863	
233	Fletcher, W., Croft, Windermere	...	...	Feb.	4,	1871
234	Foggin, Wm., Pensher Colliery, Fence Houses		Mar.	6,	1875	
235	Forrest, J., Assoc. Inst. C.E., Pentrehobin Hall, Mold, Flintshire	...	...	...	Mar.	5, 1870
236	FORSTER, G. B., M.A., Backworth House, near Newcastle-upon-Tyne	...	...	Nov.	5, 1852	
		...	...	...	(<i>Member of Council</i>)	
237	Forster, George E., Washington, Gateshead	...	...	Aug.	1,	1868
238	Forster, J. R., Water Co.'s Office, Newcastle...		July	2,	1872	

239	Forster, Richard, White House, Gateshead	...	...	Oct.	5, 1872
240	Forster, R., Trimdon Grange Colliery, Ferryhill	...	...	Sept.	5, 1868
241	Foster, George, Osmondthorpe Colliery, near Leeds	...	...	Mar.	7, 1874
242	Fothergill, J., King Street, Quay, Newcastle	...	...	Aug.	7, 1862
243	Fowler, G., Basford Hall, near Nottingham	...	...	July	4, 1861
244	Fowler, W. C., Stanton Iron Works, near Derby	...	...	Aug.	6, 1870
245	France, W., Lofthouse Mines, Saltburn-by-the-Sea	...	...	April	6, 1867
246	Franks, George, Victoria Garesfield, Lintz Green	...	...	Feb.	6, 1875
247	Frazer, B., Quay, Newcastle-upon-Tyne	...	...	Oct.	4, 1866
248	Frazer, W., 5, East Parade, Newcastle-upon-Tyne	...	...	Oct.	4, 1866
249	Frazier, Prof. B. W., Lehigh University, Bethlehem, Penns., U.S.	...	...	...	Nov. 2, 1872
250	Fryar, M., C.E.	...	...	...	Sept. 7, 1867
251	Furness, H. D., Whickham, Gateshead-on-Tyne	...	...	Dec.	2, 1871
252	Gainsford, T. R., Whiteley Wood Hall, near Sheffield	Nov.	5, 1864		
253	Galloway, R. L., Barmoor, Ryton	...	...	Dec.	6, 1873
254	Gardner, Walter, M.E., The Stone House, Rugeley	...	...	Feb.	14, 1874
255	Garforth, W. E., Lord's Field Coll., Ashton-under-Lyne	Aug.	2, 1866		
256	Garside, John, Plashymaston Colliery, Ruabon	...	...	Nov.	9, 1874
257	Gerrard, John, Westgate, Wakefield	...	...	Mar.	5, 1870
258	Gill, Harry, Consulting Engineer, Newcastle	...	...	May	2, 1874
259	Gillett, F. C., Midland Road, Derby	...	...	July	4, 1861
260	Gilmour, D., Gilmilnscroft Colliery, nr Auckinleck, N.B.	Feb.	3, 1872		
261	Gilpin, Edwin, 26, Spring Gardens, Halifax, Nova Scotia	April	5, 1873		
262	Gilroy, G., Ince Hall Colliery, Wigan, Lancashire	...	...	Aug.	7, 1856
263	Gilroy, S. B., Assistant Gov. Inspector of Mines, Stone	Sept.	5, 1868		
264	Gjers, John, Southfield Villas, Middlesbro'	...	...	June	7, 1873
265	Goddard, D. H., Newcastle-on-Tyne	...	...	July	2, 1872
266	Goddard, F. R., Accountant, Newcastle-on-Tyne	...	...	Nov.	9, 1874
267	Goddard, W., Golden Hill Coll., Longton, No. Stafford	Mar.	6, 1862		
268	Gooch, G. H., Lintz Colliery, Burnopfield, Gateshead	...	...	Oct.	3, 1856
269	Goodman, A., Walker Iron Works, Newcastle-on-Tyne	Sept.	5, 1868		
270	Gott, Wm. L., Redheugh Colliery, Gateshead-on-Tyne	Sept.	3, 1864		
271	Grace, E. N., Dhadka, Assensole, Bengal, India	...	...	Feb.	1, 1868
272	Grant, J. H., care of C. Grant, 69, Lower Circular Street, Calcutta	...	...	...	Sept. 4, 1869
273	Gray, Thomas, Underhill, Taibach, South Wales	...	...	June	5, 1869
274	Greaves, J. O., M.E., St. John's, Wakefield	...	...	Aug.	7, 1862

- 275 Green, J. T., 5, Victoria Pl., Newport, Monmouthshire Dec. 3, 1870
- 276 GREEN, W., JUN., Garesfield Colliery, Blaydon-on-Tyne
(*Member of Council*) Feb. 4, 1853
- 277 Greener, John, General Manager, Vale Colliery, Pictou,
Nova Scotia Feb. 6, 1875
- 278 Greener, Thomas, Benton Lodge, Darlington... .. Aug. 3, 1865
- 279 Greenwell, G. C., F.G.S., Poynton and Worth Collieries,
Stockport Aug. 21, 1852
- 280 Greenwell, G. C., jun., Poynton, near Stockport ... Mar. 6, 1869
- 281 Greig, D., Leeds Aug. 2, 1866
- 282 Grey, C. G., 55, Parliament Street, London May 4, 1872
- 283 Grieves, David, Brancepeth Colliery, Willington, Co.
Durham Nov. 9, 1874
- 284 Griffith, N. R., 13, Grosvenor Road, Wrexham 1866
- 285 Grimshaw, E. J., Cowley Hill, St. Helen's, Lancashire Sept. 5, 1868
- 286 Grimshaw, W. J., Stand Lane Coll., Radcliffe, Manchstr. Nov. 1, 1873
- 287 Ground, H. N., Tyne Main Colliery, Gateshead ... July 2, 1872
- 288 Guinotte, Lucien, Directeur des Charbonnages de
Mariemont et de Bascomp, Mons Sept. 2, 1871
- 289 Haggie, P., Gateshead 1854
- 290 Haines, J. Richard, Adderley Green Coll., nr. Longton Nov. 9, 1874
- 291 Hair, T. C., Shire Moor Colliery, Earsdon, Northumld. Feb. 1, 1873
- 292 Hales, C., Nerquis Cottage, Nerquis, nr. Mold, Flintsh. 1865
- 293 Hall, Edward, 24½ Bigg Market, Newcastle Oct. 3, 1868
- 294 Hall, F. W., 23, St. Thomas' Street, Newcastle Aug. 7, 1869
- 295 Hall, George, South Garesfield Colliery, Lintz Green ... Mar. 6, 1875
- 296 Hall, Henry, Rainhill, Lancashire Aug. 2, 1866
- 297 Hall, M., Pease's West Collieries, *via* Darlington ... Sept. 5, 1868
- 298 Hall, M. S., M.E., Woodlesford, near Leeds Feb. 14, 1874
- 299 Hall, W., Springhill Mines, Cumberland Co., Nova Scotia Sept. 13, 1873
- 300 Hall, William F., Haswell Colliery, Fence Houses ... May 13, 1858
- 301 Hann, Edmund, Brotton, near Saltburn-by-the-Sea ... Sept. 5, 1868
- 302 Hargreaves, William, Rothwell Haigh, Leeds Sept. 5, 1868
- 303 Harkness, A., Birtley Iron Works, Fence Houses ... Dec. 5, 1868
- 304 Harper, J. P., All Saints' Chambers, Derby Feb. 2, 1867
- 305 Harper, Matthew, Whitehaven Oct. 1, 1863
- 306 Harrison, R., Eastwood Collieries, Nottingham 1861
- 307 Harrison, T., Great Western Railway Co. Limited,
Pontypridd, Glamorganshire Aug. 2, 1873

308	Harrison, T. E., C.E., Central Station, Newcastle	...	May	6, 1853
309	Harrison, W. B., Brownhills Collieries, near Walsall	...	April	6, 1867
310	Haswell, G. H., 11, South Preston Terr., North Shields	...	Mar.	2, 1872
311	Hay, J., jun., Widdrington Colliery, Ashington	...	Sept.	4, 1869
312	HAWTHORN, T., 98, Rye Hill, Newcastle-on-Tyne			
	(Member of Council)		Dec.	6, 1866
313	Hawthorn, W., C.E., 92, Pilgrim Street, Newcastle	...	Mar.	4, 1853
314	Head, J., Newport Rolling Mills, Middlesbro'	...	Oct.	2, 1869
315	Heckels, Matthew, Boldon Colliery, Durham	...	April	11, 1874
316	Heckels, R., Wearmouth Colliery, Sunderland	...	Nov.	5, 1852
317	Hedley, Edward, Osmaston Street, Derby	...	Dec.	2, 1858
318	Hedley, J. J., Consett Collieries, Leadgate, Co. Durham	...	April	6, 1872
319	Hedley, J. L., 3, Elm Vale, Fairfield, Liverpool	...	Feb.	5, 1870
320	Hedley, T. F., Valuer, Sunderland	..	Mar.	4, 1871
321	HEDLEY, W. H., Consett Collieries, Medomsley, New-			
	castle-on-Tyne	...	(Member of Council)	1864
322	Henderson, H., Pelton Colliery, Chester-le-Street	...	Feb.	14, 1874
323	Henderson, John, Leazes House, Durham	...	Mar.	5, 1870
324	Heppell, T., Leafield House, Birtley, Fence Houses	...	Aug.	6, 1863
325	Heppell, W. Brancepeth Coll., Willington, Co. Durham	...	Mar.	2, 1872
326	Herdman, J., Park Crescent, Bridgend, Glamorganshire	...	Oct.	4, 1860
327	Heslop, C., Upleatham Mines, Marske	...	Feb.	1, 1868
328	Heslop, Grainger, Whitwell Colliery, Sunderland	...	Oct.	5, 1872
329	Heslop, J., Hucknall Torkard Coll., near Nottingham	...	Feb.	6, 1864
330	Hetherington, D., Coxlodge Colliery, Newcastle	...		1859
331	Hetherington, Robert, Coanwood, Haltwhistle	...	Nov.	1, 1873
332	Hewitt, G. C., Coal Pit Heath Colliery, near Bristol	...	June	3, 1871
333	Hewlett, A., Haigh Colliery, Wigan, Lancashire	...	Mar.	7, 1861
334	Hick, G. W., 14, Blenheim Terrace, Leeds	...	May	4, 1872
335	Higson, Jacob, 94, Cross Street, Manchester	...		1861
336	Higson, P., jun., Hope View, Eccles, near Manchester	...	Aug.	3, 1865
337	Hilton, J., Standish and Shevington Colls., near Wigan	...	Dec.	7, 1867
338	Hilton, T. W., Wigan Coal & Iron Co., Limited, Wigan	...	Aug.	3, 1865
339	Hodgkin, T., Banker, Newcastle-on-Tyne	...	Sept.	2, 1871
340	Hodgson, R., Whitburn, Sunderland	...	Feb.	7, 1856
341	Holliday, Martin, M.E., Peases' West Collieries, Crook	...	May	1, 1875
342	Holmes, C., Grange Hill, near Bishop Auckland	...	April	11, 1874
343	Homer, Charles James, Chatterley Hall, Tunstall	...	Aug.	3, 1865
344	Hood, A., 6, Bute Crescent, Cardiff	...	April	18, 1861
345	Hopton, James, Killingbeck Colliery, near Leeds	...	Dec.	5, 1874

346	Hornsby, H., Whitworth Colliery, Ferryhill	...	Aug.	1, 1874
347	Horsfall, J. J., Bradley Green Colliery, near Congleton	Mar.	2, 1865	
348	Horsley, W., Whitehill Point, Percy Main	...	Mar.	5, 1857
349	Hoskold, H. D.	...	April	1, 1871
350	Howard, W. F., 13, Cavendish Street, Chesterfield	...	Aug.	1, 1861
351	Hoyt, J., Acadia Coal Mines, Pictou, Nova Scotia	...	May	8, 1869
352	Hudson, James, Albion Mines, Pictou, Nova Scotia	...		1862
353	Humble, John, West Pelton, Chester-le-Street	...	Mar.	4, 1871
354	Humble, Jos., jun., Pemberton Collieries, near Wigan	June	2, 1866	
355	Humble, W. J., Forth Banks West Factory, Newcastle	Sept.	1, 1866	
356	Hunt, A. H., Quayside, Newcastle-upon-Tyne	...	Dec.	6, 1862
357	Hunter, J., jun., Silksworth and Worsbro' Park Col- lieries, near Barnsley	...	Mar.	6, 1869
358	Hunter, W., Cannock, Staffordshire	...	Oct.	3, 1861
359	Hunter, Wm., Charlaw Colliery Office, Quay, Newcastle	Aug.	21, 1852	
360	Hunter, W. S., Moor Lodge, Newcastle-upon-Tyne	...	Feb.	1, 1868
361	Hunting, Charles, Fence Houses	...	Dec.	6, 1866
362	Huntsman, Benjamin, West Retford Hall, Retford	...	June	1, 1867
363	Hurd, F., Grove House, Walton, near Wakefield	...	Dec.	4, 1869
364	Hurst, T. G., F.G.S., Riding Mill, Northumberland	...	Aug.	21, 1852
365	Hutchings, W. M., 5, Bouverie St., Fleet St., London	Sept.	5, 1868	
366	Hutchinson, G., Howden Colliery, Darlington	...	July	2, 1872
367	Hybner, Josef, Mährisch, Ostrau Moravia, Austria	...	Aug.	1, 1874
368	Hyslop, J. S., Belmont Mines, Guisboro'	...	April	1, 1871
369	Jackson, C. G., Wigan Coal and Iron Co. Limited, Wigan	June	4, 1870	
370	Jackson, W., Cannock Chase Collieries, Walsall	...	Feb.	14, 1874
371	Jackson, W. G., Lime Street, Saltburn	...	June	7, 1873
372	Jameson, John, Printing Court Chambers, Newcastle	Nov.	6, 1869	
373	Jarratt, J., Broomside Colliery Office, Durham	...	Nov.	2, 1867
374	Jeffcock, T. W., 18, Bank Street, Sheffield	...	Sept.	4, 1869
375	Jenkins, W., M.E., Ocean S.C. Collieries, Ystrad, near Pontypridd, South Wales	...	Dec.	6, 1862
376	Jenkins, Wm., Consett Iron Works, Consett, Lintz Green	May	2, 1874	
377	Johnasson, J., Leadenhall Street, London, E.C.	...	July	2, 1872
378	Johnson, Henry, Dudley, Worcestershire	...	Aug.	7, 1869
379	Johnson, John, M. Inst. C.E., F.G.S., Osborne Terrace, Jesmond Road, Newcastle	...	Aug.	21, 1852
380	Johnson, John, Ruabon Coal Company, Ruabon	...	Mar.	7, 1874
381	Johnson, R. S., Sherburn Hall, Durham	...	Aug.	21, 1852

382	Johnson, W. J., W.B. Lead Works, Allendale	...	April	6, 1872
383	Johnston, T., North Fenham Colliery, Newcastle	...	April	6, 1872
384	Joicey, E., Coal Owner, Newcastle-on-Tyne	...	April	6, 1872
385	Joicey, John, Newton Hall, Stocksfield-on-Tyne	...	Sept.	3, 1852
386	Joicey, J. G., Forth Banks West Factory, Newcastle	...	April	10, 1869
387	Joicey, W. J., Tanfield Lea Colliery, Burnopfield	...	Mar.	6, 1869
388	Jones, John, F.G.S., Secretary, North of England Iron Trade, Middlesbro'-on-Tees	... ..	Sept.	7, 1867
389	Jordan, Robert, Ebbw Vale, South Wales	...	Nov.	9, 1874
390	Joseph, D. Davis, Ty Draw, Pontypridd, South Wales	...	April	6, 1872
391	Joseph, T., Ty Draw, near Pontypridd, South Wales	...	April	6, 1872
392	Kasalowsky, Josef, 11, Kaiser Josefs Strasse, Vienna	...	Aug.	1, 1874
393	Kelsey, William, 2, Grange Crescent, Sunderland	...	Mar.	7, 1874
394	Kendall, John D., Roper Street, Whitehaven	...	Oct.	3, 1874
395	Kendall, W., Blyth and Tyne Railway, Percy Main	...	Sept.	1, 1866
396	Kennedy, Myles, M.E., Hill Foot, Ulverstone	...	June	6, 1868
397	Key, Thomas, Gate Fulford, York	... ..	Nov.	2, 1872
398	Kimpton, J. G., 40, St. Mary Gate, Derby	...	Oct.	5, 1872
399	Kirkby, J. W., Pirnie Colliery, Leven, Fife	...	Feb.	1, 1873
400	Kirkwood, William, Larkhall Colliery, Hamilton	...	Aug.	7, 1869
401	Kirsopp, John, Team Colliery, Gateshead	...	April	5, 1873
402	Knowles, A., High Bank, Pendlebury, Manchester	...	Dec.	5, 1856
403	Knowles, A., jun., The Poplars, Hope Eccles, near Manchester...	... ..	Dec.	3, 1863
404	Knowles, John, Pendlebury Colliery, Manchester	...	Dec.	5, 1856
405	Knowles, Kaye, Little Lever Colliery, near Bolton	...	Aug.	3, 1865
406	Knowles, R. M.,	... ..	Aug.	3, 1865
407	Knowles, Thomas, Ince Hall, Wigan	...	Aug.	1, 1861
408	Kyrke, R. H. V., Nant-y-Ffrith, Wrexham, No. Wales	...	Feb.	5, 1870
409	Lackland, J. J., Port Mulgrave, Saltburn-by-the-Sea	...	Mar.	7, 1874
410	Lamb, R., Cleator Moor Colliery, near Whitehaven	...	Sept.	2, 1865
411	Lamb, R. O., Gibside, Lintz Green, Newcastle	...	Aug.	2, 1866
412	Lamb, Richard W., Coal Owner, Newcastle-on-Tyne	...	Nov.	2, 1872
413	Lambert, M. W., 9, Queen Street, Newcastle	...	July	2, 1872
414	Lancaster, John, Bilton Grange, Rugby	...	July	4, 1861
415	Lancaster, J., jun., South Bank, Milverton, Leamington	...	Mar.	2, 1865
416	Lancaster, Joshua, 4, Leaf Sq., Pendleton, Manchester	...	Aug.	3, 1865
417	Lancaster, S., Heath End Coll., near Ashley-de-la-Zouch	...	Aug.	3, 1865

418	Landale, A., Lochgelly Iron Works, Fifeshire, N.B. ...	Dec.	2, 1858
419	Lange, C., Queen Street, Newcastle-on-Tyne ...	Mar.	5, 1870
420	Laverick, J., West Rainton, Fence Houses ...	July	2, 1872
421	Lawrence, Henry, Grange Iron Works, Durham ...	Aug.	1, 1868
422	LAWS, H., Grainger Street West, Newcastle-on-Tyne		
	(Member of Council)	Feb.	6, 1869
423	Laws, John, Blyth, Northumberland ...		1854
424	Lawson, Rev. E., Longhirst Hall, Morpeth ...	Dec.	3, 1870
425	Lawson, J. P., Vale Colliery, New Glasgow, N. Scotia	Dec.	3, 1870
426	Laycock, Joseph, Low Gosforth, Northumberland ...	Sept.	4, 1869
427	Leather, J. T., Middleton Hall, Belford, Northumberland	Aug.	6, 1870
428	Lebour, G. A., Weedpark House, Dipton, Lintz Green	Feb.	1, 1873
429	Lee, George, Liverton Mines, Lofthouse, ...	June	4, 1870
430	Leslie, Andrew, Hebburn, Gateshead-on-Tyne ...	Sept.	7, 1867
431	Lever, Ellis, West Gorton Works, Manchester ...		1861
432	Lewis, G., Imperial Chambers, Derby ...	Aug.	6, 1863
433	Lewis, Henry, Annesley Colliery, near Mansfield ...	Aug.	2, 1866
434	Lewis, William Thomas, Mardy, Aberdare ...		1864
435	Liddell, G. H., Burnhope Coll., Lanchester, Co. Durham	Sept.	4, 1869
436	Liddell, J. R., Nedderton, Northumberland ...	Aug.	21, 1852
437	Liddell, M., Prudhoe Hall, Prudhoe-on-Tyne ...	Oct.	1, 1852
438	Lindop, James, Bloxwich, Walsall, Staffordshire ...	Aug.	1, 1861
439	Linsley, R., Cramlington Colliery, Northumberland	July	2, 1872
440	Linsley, S. W., Whitburn Colliery, Sunderland ...	Sept.	4, 1869
441	Lishman, John, Western Hill, Durham ...	June	2, 1866
442	Lishman, T., jun., Hetton Colliery, Fence Houses ...	Nov.	5, 1870
443	Lishman, Wm., Etherley Colliery, Darlington ...		1857
444	Lishman, Wm., Bunker Hill, Fence Houses ...	Mar.	7, 1861
445	Livesey, C., Bredbury Colliery, Bredbury, Stockport...	Aug.	3, 1865
446	Livesey, T., Prestwich Park, near Manchester ...	Aug.	1, 1861
447	Livesey, T., junr., Hatherlow House, Romilly, Cheshire	Nov.	9, 1874
448	Llewellyn, D., Glanwern Offices, Pontypool, Mon. ...	Aug.	4, 1864
449	Llewelyn, L., Aberaman, Aberdare, South Wales ...	May	4, 1872
450	Logan, Wm., Langley Park Colliery, Durham ...	Sept.	7, 1867
451	Longbotham, J., Framwellgate Colliery, near Durham	May	2, 1868
452	Longridge, J., 3, Westminster Chambers, Victoria		
	Street, Westminster, London, S.W. ...	Aug.	21, 1852
453	Low, W., Vron Colliery, Wrexham, Denbighshire ...	Sept.	6, 1855
454	Lupton, A., F.G.S., Bagillt, North Wales ...	Nov.	6, 1869

455	Mackenzie, J., Tamworth House, 16, Whiteladies Road, Clifton, Bristol	...	...	...	...	Mar.	5, 1870
456	Maddison, W. P., Thornhill Collieries, near Dewsbury	Oct	6, 1859				
457	Maling, C. T., Ford Pottery, Newcastle-on-Tyne	...	Oct.	5, 1872			
458	Mammatt, J.E., C.E., Beechwood, Bramley, nr. Leeds			1864			
459	MARLEY, JOHN, Mining Offices, Darlington						
	(Member of Council)	Aug.	21, 1852				
460	Marley, J. W., *Mining Offices, Darlington	...	...	Aug.	1, 1868		
461	Marshall, F. C., Messrs. Hawthorn and Co., Newcastle	Aug.	2, 1866				
462	Marshall, J., Smithfold Coll., Little Hulton, nr. Bolton			1864			
463	Marston, W. B., Leeswood Vale Oil Works, Mold	...	Oct.	3, 1868			
464	Marten, E. B., C.E., Pedmore, near Stourbridge	...	July	2, 1872			
465	Martin, Joseph S., Bury New Road, Prestwich, near Manchester	...	...	...	...	Mar.	3, 1873
466	Martin, R. F., Colliery Office, Whitehaven	...	...	April 11, 1874			
467	Matthews, R. F., South Hetton Colliery, Fence Houses	Mar.	5, 1857				
468	Maughan, J. A., 6, Sandhill, Newcastle	...	...	Nov.	7, 1863		
469	MAY, GEORGE, Harton Colliery Offices, Tyne Dock, South Shields	...	...	(Member of Council)	Mar.	6, 1862	
470	McCreath, J., 138, West George Street, Glasgow	...	Mar.	5, 1870			
471	McCulloch, H. J., Moat House, Wood Green, London, N.	Oct.	1, 1863				
472	McCulloch, Wm., Cympermar Mountain Ash, So. Wales	Nov.	9, 1874				
473	McGhie, T., Cannock, Staffordshire	...	...	...	Oct.	1, 1857	
474	McMurtrie, J., Radstock Colliery, Bath	...	...	Nov.	7, 1863		
475	McMurtrie, W. G., Llwynypia Colliery, near Pontypridd, South Wales	...	...	...	...	Sept.	4, 1869
476	Meik, Thomas, C.E., 6, York Place, Edinburgh	...	June	4, 1870			
477	Menzies, W., King Street, Newcastle	...	...	Sept.	13, 1873		
478	Miller, Robert, Strafford Collieries, near Barnsley	...	Mar.	2, 1865			
479	Mills, John, Forth Street, Newcastle	...	...	July	2, 1872		
480	Mitchell, Charles, Shipbuilder, Newcastle	...	...	April 11, 1874			
481	Mitchell, Joseph, jun., Worsbro' Dale, near Barnsley	...	Feb.	14, 1874			
482	Mitchinson, R., jun., Pontop Colliery, Lintz Green Station, Co. Durham	...	...	...	...	Feb.	4, 1865
483	Moffatt, T., Montreal Iron Ore Works, Whitehaven	...	Sept.	4, 1869			
484	Monkhouse, Jos., Yeat House, Frizington, Whitehaven	June	4, 1863				
485	Moor, T., North Seaton Colliery, Morpeth	...	...	Oct.	3, 1868		
486	Moor, W., Engineer, Hetton Colliery, Fence Houses	...	Oct.	3, 1874			
487	Moore, T. H., Smeaton Park, Inveresk, Edinburgh	...	Feb.	2, 1867			
488	MORISON, D. P., 21, Collingwood Street, Newcastle						
	(Member of Council)			1861			

489	Morris, W., Waldrige Colliery, Chester-le-Street, Fence Houses	...	...	...	...	...	1858
490	Morrison, Jas., 34, Grey Street, Newcastle-upon-Tyne	Aug.	5,	1853			
491	Morton, H. T., Lambton, Fence Houses	...	...	Aug.	21,	1852	
492	Moseley, Walter, 9, Parr Street, Liverpool	...	...	Nov.	9,	1874	
493	Muckle, John, Monk Bretton, Barnsley	...	...	Mar.	7,	1861	
494	Mulcaster, W., jun., M.E., Croft House, Aspatria, near Carlisle	...	...	...	...	Dec.	3, 1870
495	Mulvany, W. T., Pèmpèlfort, Dusseldorf-on-the-Rhine	Dec.	3,	1857			
496	Mundle, W., Redesdale Mines, Bellingham	...	...	Aug.	2,	1873	
497	Murray, George, Engineer, Sandhill, Newcastle	...	...	Nov.	9,	1874	
498	Murray, T. H., Chester-le-Street, Fence Houses	...	...	April	18,	1861	
499	Nanson, J., 4, Queen Street, Newcastle-on-Tyne	...	...	Dec.	4,	1869	
500	Nasse, Herr Bergassessor, Louisenthal, Saarbrucken, Prussia	...	...	...	...	Sept.	4, 1869
501	Naylor, J. T., 10, West Clayton Street, Newcastle	...	...	Dec.	6,	1866	
502	NELSON, J., C.E., King's House Engine Works, Sunderland	...	...	...	...	(Member of Council)	Oct. 4, 1866
503	Nevin, John, Mirfield, Yorkshire	...	...	...	May	2,	1868
504	NEWALL, R. S., Ferndene, Gateshead					(Member of Council)	May 2, 1863
505	Newby, J. E., Usworth Colliery, by Washington Station, County Durham	...	...	...	...	Oct.	2, 1869
506	Nicholson, E., jun., Beamish Colliery, Chester-le-Street	Aug.	7,	1869			
507	Nicholson, J. W., Greenside Colliery, Milton, Carlisle	Oct.	11,	1873			
508	Nicholson, Marshall, Middleton Hall, Leeds	...	...	Nov.	7,	1863	
509	Nicholson, R., Blaydon-on-Tyne	...	...	...	July	2,	1872
510	Nicholson, T., Park Lane Engine Works, Gateshead	...	...	Dec.	4,	1869	
511	Nicholson, W., Seghill Colliery, Newcastle	...	...	Oct.	1,	1863	
512	Noble, Captain, Jesmond, Newcastle-upon-Tyne	...	...	Feb.	3,	1866	
513	North, F. W., F.G.S., Rowley Hall Colliery, Dudley, Staffordshire	...	...	...	...	Oct.	6, 1864
514	Ogden, John M., Solicitor, Sunderland	...	...	Mar.	5,	1857	
515	Pacey, T., Bishop Auckland	...	...	...	...	April	10, 1869
516	Page, Wm., 10, Grove Street, Newcastle	...	...	Mar.	6,	1875	
517	Palmer, A. S., Wardley Colliery, Durham	...	...	July	2,	1872	
518	Palmer, C.M., M.P., Quay, Newcastle-upon-Tyne	...	...	Nov.	5,	1852	
519	Palmer, John B., Jarrow-on-Tyne	...	...	...	April	1,	1871

520	Panton, F. S., Silksworth Colliery, Sunderland	...	Oct.	5, 1867
521	Papik, Johanne, Teplitz, Bohemia	...	Feb.	5, 1870
522	Parkin, Charles E., Perran House, Perran Porth, Truro, Cornwall	...	June	5, 1875
523	Parkin, John, Duchy Peru, Newlyn East, Grampound Road, Cornwall	...	April	11, 1874
524	Parrington, M. W., Wearmouth Colliery, Sunderland	...	Dec.	1, 1864
525	Parton, T., F.G.S., Ash Cottage, Birmingham Road, West Bromwich	...	Oct.	2, 1869
526	Pattinson, John, Analytical Chemist, Newcastle	...	May	2, 1868
527	Pattison, John, Engineer, Naples	...	Nov.	9, 1874
528	Pattison, W., Westminster Colliery, Wrexham	...	Oct.	11, 1873
529	Pattison, W., jun., Ffrwd Coll. and Ironworks, Wrexham	...	Oct.	11, 1873
530	Patton, John, Vine Lodge, Sunderland	...	April	6, 1872
531	Peace, M. W., Wigan, Lancashire	...	July	2, 1872
532	Peacock, David, Horsley, Tipton	...	Aug.	7, 1869
533	Pearce, F. H., Bowling Iron Works, Bradford	...	Oct.	1, 1857
534	Pearson, J. E., Golborne Park, near Newton-le-Willows	...	Feb.	3, 1872
535	Pease, J. W., M.P., Hutton Hall, Guisbro', Yorkshire	...	Mar.	5, 1857
536	Peel, John, Wharnccliffe and Silkstone Collieries, Wortley, near Sheffield	...	Nov.	1, 1860
537	Peile, William, Oakfield Street, Roath, Cardiff	...	Oct.	1, 1863
538	Penman, J. Hugh, Clarence Buildings, 2, Booth Street, Manchester	...	Mar.	7, 1874
539	Perrot, S. W., 39, Kronprinzen Strasse, Dusseldorf	...	June	2, 1866
540	Philipson, H., 8, Queen Street, Newcastle-on-Tyne	...	Oct.	7, 1871
541	Pickersgill, T., Waterloo Main Colliery, near Leeds	...	June	5, 1869
542	Pickup, P. W., Dunkenhalgh Colls., Accrington, Lanc.	...	Feb.	6, 1875
543	Piggford, J., Risca House, Risca, near Newport, Mon.	...	Aug.	2, 1866
544	Pilkington, Wm., jun., St. Helen's, Lancashire	...	Sept.	6, 1855
545	Potter, Addison, Heaton Hall, Newcastle-on-Tyne	...	Mar.	6, 1869
546	Potter, C. J., Heaton Hall, Newcastle-on-Tyne	...	Oct.	3, 1874
547	Price, J. R., Standish, near Wigan	...	Aug.	7, 1869
548	Priestman, Jon., Coal Owner, Newcastle-on-Tyne	...	Sept.	2, 1871
549	RAMSAY, J. A., Washington Colliery, near Durham (Member of Council)	...	Mar.	6, 1869
550	RAMSAY, J. T., Walbottle Hall, near Blaydon-on-Tyne (Member of Council)	...	Aug.	3, 1853
551	Ramsay, T. D., So. Durham Colliery, via Darlington	...	Mar.	1, 1866

552	Redmayne, J. M., Chemical Manufacturer, Gateshead	July	2, 1872
553	Reed, Robert, Felling Colliery, Gateshead	... .. Dec.	3, 1863
554	Reefeen, Wm., Teplitz, Bohemia	... .. Oct.	5, 1872
555	Rees, Daniel, Glandare, Aberdare	... ..	1862
556	Reid, Andrew, Newcastle-on-Tyne	... .. April	2, 1870
557	Reynolds, J. J., M.E., Leigh Road, Atherton, near Manchester	... .. April	3, 1875
558	Richards, G. C., M.E., Woodhouse, near Sheffield	... June	5, 1875
559	Richardson, E., 2, Queen Street, Newcastle-on-Tyne...	Feb.	5, 1870
560	Richardson, H., Backworth Colliery, Newcastle	... Mar.	2, 1865
561	Richardson, J. W., Iron Shipbuilder, Newcastle-on-Tyne	Sept.	3, 1870
562	Richardson, M., West Stanley Colliery, Chester-le-St.	April	3, 1875
563	Ridley, G., Trinity Chambers, Newcastle-on-Tyne	... Feb.	4, 1865
564	Ridley, J. H., R. and W. Hawthorn's, Newcastle	... April	6, 1872
565	Ridyard, John, Walkden, near Bolton-le-Moor	... Nov.	9, 1874
566	Riska, Franz, Machinen Fabrik, Prague, Bohemia	... Aug.	1, 1874
567	Ritson, U. A., 6, Queen Street, Newcastle-on-Tyne	... Oct.	7, 1871
568	Robertson, W., M.E., 123, St. Vincent Street, Glasgow	Mar.	5, 1870
569	Robinson, G. C., Brereton and Hayes Collieries, Rugeley, Staffordshire	... .. Nov.	5, 1870
570	Robinson, H., C.E., 7, Westminster Chambers, London	Sept.	3, 1870
571	Robinson, R., jun., Howlish Hall, near Bp. Auckland	Feb.	1, 1868
572	Robinson, R. H., Staveley Works, near Chesterfield	... Sept.	5, 1868
573	Robson, D. W., Onston, Chester-le-Street	... .. Nov.	9, 1874
574	Robson, E., Cassop and Tyne Main Colliery Offices, Middlesbro'-on-Tees	... .. April	2, 1870
575	Robson, J. S., Butterknowle Colliery, <i>via</i> Staindrop, Darlington...	... ..	1853
576	Robson J. T., Cambuslang, Glasgow	... .. Sept.	4, 1869
577	Robson, M., Coppa Colliery, near Mold, Flintshire	... May	4, 1872
578	Robson, Thomas, Lumley Colliery, Fence Houses	... Oct.	4, 1860
579	Robson, W. C., Walbottle Colliery, near Newcastle	... Sept.	4, 1869
580	Rogerson, J., Weardale Iron and Coal Co., Newcastle	Mar.	6, 1869
581	Roscamp, J., Rosedale Lodge, nr. Pickering, Yorkshire	Feb.	2, 1867
582	Roseby, John, Haverholme House, Brigg, Lincolnshire	Nov.	2, 1872
583	Ross, A., Shipcote Colliery, Gateshead	... .. Oct.	1, 1857
584	Ross, E. A., Tondy Coal Works, Bridgend, Glam.	... April	11, 1874
585	Ross, J. A. G., 34, Collingwood Street, Newcastle	... July	2, 1872
586	Rosser, W., Mineral Surveyor, Llanelly, Carmarthensh.		1856
587	Rothwell, R. P., 27, Park Place, New York	... .. Mar.	5, 1870

588	Routledge, T., Lorway Coal Co., Limited, Sydney, Cape Breton	...	...	...	...	Dec.	3, 1870
589	Routledge, Wm., Sydney, Cape Breton	...	...	...	...	Aug.	6, 1857
590	Rusby, W. J., 99, Cannon Street, London, E.	...	...	...	...	Aug.	1, 1868
591	Rutherford, J., Halifax, Nova Scotia	...	...	...	...		1866
592	Rutherford, W., Marden House, Whitley, Newcastle	Oct.	3, 1874				
593	Rutter, Thos., Blaydon Main Coll., Blaydon-on-Tyne	May	1, 1875				
594	Saint, Geo., Llangennech Colliery, Llanelly, South Wales	April	11, 1874				
595	Sanderson, R. Burdon, 33, Westgate Road, Newcastle		1852				
596	Scarth, W. T., Raby Castle, Darlington	...	...	April	4, 1868		
597	Scott, Andrew, Broomhill Colliery, Acklington	...	Dec.	7, 1867			
598	Sconlar, G., Parkside, Frizington, Cumberland	...	July	2, 1872			
599	Seddon, J. F., Great Harwood Collieries, nr. Accrington	June	1, 1867				
600	Seddon, W., Lark Hill Terrace, Edge Lane Road, Old- ham, Lancashire	...	...	...	...	Oct.	5, 1865
601	Shallis, F. W., 16, Redcliffe Street, South Kensington, London,	...	...	...	...	April	6, 1872
602	Shaw, W., jun., Wolsingham, <i>via</i> Darlington	...	June	3, 1871			
603	Sheppard, F. C., 71, Maple St., Newcastle-on-Tyne	...	Nov.	2, 1872			
604	Shiel, John, Usworth Colliery, County Durham	...	May	6, 1871			
605	Shield, H., Lamb's Cottage, Gilesgate Moor, Durham	Mar.	6, 1862				
606	Shone, Isaac, Pentrefelin House, Wrexham	...	...	1858			
607	Shortrede, T., Park House, Wiustanley, Wigan	...	April	3, 1856			
608	Shute, C. A., Westoe, South Shields	...	...	April	11, 1874		
609	Simpson, J., Heworth Colliery, nr. Gateshead-on-Tyne	Dec.	6, 1866				
610	Simpson, John, West Stanley Coll., Chester-le-Street...	April	3, 1875				
611	Simpson, Jos., So. Derwent Coll., <i>via</i> Lintz Green Station	Mar.	3, 1873				
612	SIMPSON, J. B., Hedgfield House, Blaydon-on-Tyne (<i>Member of Council</i>)	Oct.	4, 1860				
613	Simpson, R., Moor House, Ryton-on-Tyne	...	...	Aug.	21, 1852		
614	Slinn, T., Radcliffe House, Acklington	...	...	July	2, 1872		
615	Small, G., Kilburne Colliery, near Derby	...	...	June	4, 1870		
616	Smallshaw, J., Westleigh Coll., Leigh, nr. Manchester	Nov.	9, 1874				
617	Smith, C. J., 16, Whitehall Place, Westminster, London, S.W.	...	...	...	...	July	2, 1872
618	Smith, E. J., 16, Whitehall Place, Westminster, London	Oct.	7, 1858				
619	Smith, G. F., Bridgewater Offices, Manchester	...	Aug.	5, 1853			
620	Smith, J., Bickershaw Colliery, Wigan	...	...	Mar.	7, 1874		
621	Smith, R. A., 74, Osmaston Street, Derby	...	...	Nov.	9, 1874		

622	Smith, T. E., M.P., Gosforth House, Dudley, Northd.	Feb.	5,	1870
623	Smith, T. E., Phoenix Foundry, Newgate St., Newcastle	Dec.	5,	1874
624	Smith, T. M., 1, Chapel Place, Delahay Street, Westminster, London	Sept.	2,	1871
625	Sneddon, J., 149, West George Street, Glasgow	July	2,	1872
626	Snowdon, T., jun., West Bitchburn Colliery, near Towlaw, <i>via</i> Darlington	Sept.	4,	1869
627	Sopwith, A., Cannock Chase Collieries, near Walsall	Aug.	1,	1868
628	Sopwith, T., F.G.S., etc., 103, Victoria Street, Westminster, London, S.W.	May	6,	1853
629	Sopwith, T., jun., South Derwent Coll., near Annfield Plain, Co. Durham	Nov.	2,	1867
630	Southern, R., Burleigh House, The Parade, Tredegarville, Cardiff	Aug.	3,	1865
631	Southworth, Thos., Hindley Green Collieries, nr. Wigan	May	2,	1874
632	Spark, H. K., Darlington			1856
633	Sparkes, C., care of J. Dunning, Esq., Southfield Villas, Middlesbro'	Sept.	5,	1868
634	Spence, G., Coltness Iron Works, New Mains, N.B.	June	7,	1873
635	Spence, James, Clifton and Millgramfitz Collieries, Workington	Nov.	9,	1874
636	Spence, John P., Borough Surveyor, Tynemouth	Dec.	5,	1874
637	Spencer, John, Westgate Street, Newcastle-on-Tyne	Sept.	4,	1869
638	Spencer, M., Newburn, near Newcastle-on-Tyne	Sept.	4,	1869
639	Spencer, T., Ryton, Newcastle-on-Tyne	Dec.	6,	1866
640	Spencer, W., Cross House Chambers, Westgate Road, Newcastle	Aug.	21,	1852
641	Spooner, P., Haswell Colliery, Fence Houses	Dec.	4,	1869
642	Spours, J. L., Pensbury Street, Darlington	April	11,	1874
643	STEAVENSON, A. L., Durham (<i>Member of Council</i>)	Dec.	6,	1855
644	Steavenson, D.F., B.A., LL.B., Barrister-at-Law, Cross House, Westgate Street, Newcastle-on-Tyne	April	1,	1871
645	Steele, Chas., Bolton Colliery, Mealsgate, Cumberland	June	7,	1873
646	Steele, Charles R., Ellenborough Colliery, Maryport	Mar.	3,	1864
647	Stenson, W. T., Whitwick Coll., Coalville, nr. Leicester	Aug.	5,	1853
648	Stephenson, G. R., 24, Great George Street, Westminster, London, S.W.	Oct.	4,	1860
649	Stephenson, W. H., Elswick House, Newcastle	Mar.	7,	1867
650	Stevenson, Archibald, South Shields	Sept.	2,	1871
651	Stobart, H. S., Witton-le-Wear, Darlington	Feb.	2,	1854

652	Stobart, W., Wearmouth Colliery, Sunderland	...	July	2, 1872
653	Stokoe, Joseph, Houghton-le-Spring, Fence Houses	...	April	11, 1874
654	Straker, John, Stagshaw House, Corbridge-on-Tyne	...	May	2, 1867
655	Straker, J. H., Willington House, Co. Durham	...	Oct.	3, 1874
656	Stratton, T. H. M., Seaham Colliery, Sunderland	...	Dec.	3, 1870
657	Sutherst, Thos., Cleveland Iron Works, Guisbro'	...	Nov.	9, 1874
658	Swallow, John, East Boldon, Co. Durham	...	Aug.	6, 1863
659	Swallow, John, East Castle Collieries, Annfield Plain, Lintz Green	...	May	2, 1874
660	Swallow, R. T., Springwell, Gateshead	...		1862
661	Swan, Charles, Wallsend, Newcastle	...	April	11, 1874
662	Swan, H. F., Shipbuilder, Newcastle-on-Tyne	...	Sept.	2, 1871
663	Swan, J. G., Upsall Hall, near Middlesbro'	...	Sept.	2, 1871
664	Taylor, George, Brotton Mines, Saltburn-by-the-Sea	...	June	5, 1875
665	Taylor, Hugh, 8, Queen Street, Quay, Newcastle	...	Sept.	5, 1856
666	Taylor, John, Earsdon, Newcastle-upon-Tyne	...	Aug.	21, 1852
667	Taylor, John B., The Mount, Clent, Stourbridge	...	May	3, 1873
668	Taylor, T., Chipchase Castle, Northumberland	...	July	2, 1872
669	Taylor-Smith, Thomas, Urpeth Hall, Chester-le-Street	...	Aug.	2, 1866
670	Terry, E., M.E., 269, Castle Street, Dudley	...	Sept.	13, 1873
671	Thomas, A., Bilson House, near Newnham, Glouce.	...	Mar.	2, 1872
672	Thompson, Astley, Kidwelly, Carmarthenshire	...		1864
673	Thompson, James, Bishop Auckland	...	June	2, 1866
674	Thompson, James A., So. Derwent Colliery, Annfield Plain, Lintz Green	...	Oct.	3, 1874
675	Thompson, John, Marley Hill Colliery, Gateshead	...	Oct.	4, 1860
676	Thompson, John, Boughton Hall, Chester	...	Sept.	2, 1865
677	Thompson, J., Norley Colliery, Wigan, Lancashire	...	April	6, 1867
678	Thompson, Jos. F., Manvers Main Coll., Rotherham	...	Feb.	6, 1875
679	Thompson, R., jun., North Brancepeth Coll., nr. Durham	...	Sept.	7, 1867
680	Thompson, T. C., Milton Hall, Carlisle	...	May	4, 1854
681	Thomson, G., Manager of Ironworks, Pen-y-Bryn, Ruabon	...	Nov.	9, 1874
682	Thorpe, R. S., 17, Picton Place, Newcastle	...	Sept.	5, 1868
683	Thubron, N., Merthyr Dare Colliery, Merthyr Tydvil	...	Oct.	3, 1874
684	Tinn, J., C.E., Ashton Iron Rolling Mills, Bower Ashton, Bristol	...	Sept.	7, 1867
685	Toller, J. E., Royal Engineers	...	July	2, 1872
686	Tone, J. F., C.E., Pilgrim Street, Newcastle-on-Tyne	...	Feb.	7, 1856

687	Truran, M., Dowlais, Glamorgan	...	...	...	Dec.	1, 1859
688	Turner, W. B., C. and M.E., Sella Park, <i>via</i> Carnforth	...	...	...	Dec.	7, 1867
689	Tylden-Wright, C., Shireoaks Coll., Worksop, Notts.	...	...	...		1862
690	Tyzack, D., Taensin, Formosa, care of the Commis- sioner of Customs, Amoy, China	...	...	...	Feb.	14, 1874
691	Ure, J. F., Engineer, Tyne Commissioners, Newcastle	May	8,	1869		
692	Vaughan, Thomas, Middlesbro'-on-Tees	...	...	...		1857
693	Vaughan, W. S., 10, Broad Chare, Newcastle-on-Tyne	Nov.	1,	1873		
694	Vondracek, Vladimir, Mährisch, Moravia, Austria	...	Aug.	1, 1874		
695	Wadham, E., C. and M.E., Millwood, Dalton-in-Furness	Dec.	7,	1867		
696	Wake, H. H., River Wear Commissioners, Sunderland	...	Feb.	3, 1872		
697	Waldo-Sibthorp, M. R., Saltburn-by-the-Sea	...	June	6, 1874		
698	Walker, G. W., Bulwell, Notts.	...	Sept.	7, 1867		
699	Walker, J. S., 15, Wallgate, Wigan, Lancashire	...	Dec.	4, 1869		
700	Walker, T. F., 58, Oxford Street, Birmingham	...	April	11, 1874		
701	Walker, W., Saltburn-by-the Sea	...	Mar.	5, 1870		
702	Wallace, Henry, Trench Hall, Gateshead	...	Nov.	2, 1872		
703	Wallace, J., 3, St. Nicholas' Bldgs., Newcastle-on-Tyne	Sept.	13,	1873		
704	Wand, B. W., Cliff House, Southwold, Suffolk	...	Dec.	5, 1874		
705	Ward, H., Priestfields Iron Works, Oaklands, Wolver- hampton	...	Mar.	6, 1862		
706	Wardale, John D., M.E., Redheugh Engine Works, Gateshead	...	May	1, 1875		
707	Wardell, S. C., Doe Hill House, Alfreton	...	April	1, 1865		
708	Warrington, J., Worsborough Hall, near Barnsley	...	Oct.	6, 1859		
709	Watkin, Wm. J. L., Pemberton Colliery, Wigan	...	Aug.	7, 1862		
710	Watson, H., High Bridge, Newcastle-upon-Tyne	...	Mar.	7, 1868		
711	Watson, M., Shildon Lodge Colliery, Darlington	...	Mar.	7, 1868		
712	Webster, R. C., Ruabon Coll., Ruabon, Denbighshire	Sept.	6,	1855		
713	Weeks, J. G., Bedlington Colliery, Bedlington	...	Feb.	4, 1865		
714	Westmacott, P. G. B., Elswick Iron Works, Newcastle	June	2,	1866		
715	Whaley, John, Coanwood Colliery, Haltwhistle	...	Feb.	1, 1873		
716	Whaley, Thomas, Orrell Mount, Wigan	...	Aug.	2, 1866		
717	White, H., Cassop Colliery, Trimdon Grange	...		1866		
718	White, J. F., M.E., Wakefield	...	July	2, 1872		
719	Whitelaw, A., 168, West George Street, Glasgow	...	Mar.	5, 1870		

720	Whitelaw, John, 19, London Street, Edinburgh	...	Feb.	5, 1870
721	Whitelaw, T., Shields and Dalzell Collieries, Motherwell	April	6, 1872	
722	Whittem, Thos. S., Wyken Colliery, near Coventry	...	Dec.	5, 1874
723	Whitwell, T., Thornaby Iron Works, Stockton-on-Tees	Sept.	5, 1868	
724	Widdas, C., No. Bitchburn Coll., Howden, Darlington	Dec.	5, 1868	
725	Wigram, R., Steam Plough Works, Leeds	...	Feb.	6, 1875
726	Wild, H. F., Stockport, Columbia Co., New York, U.S.	Oct.	3, 1874	
727	Wild, J. G., Monkwood and Barlow Lees Collieries, near Chesterfield	...	Oct.	5, 1867
728	Wilkinson, W., 1, Joseph St., Kyo, <i>via</i> Lintz Green	...	Mar.	3, 1873
729	Williams, E. (Bolckow, Vaughan, & Co.), Middlesbro'	Sept.	2, 1865	
730	Williams, J. J., Holywell, Flintshire	...	Nov.	2, 1872
731	Williams, John L., Mold, Flintshire	...	Nov.	2, 1872
732	Williamson, John, Chemical Manufacturer, So. Shields	Sept.	2, 1871	
733	Williamson, John, Cannock, &c., Collieries, Hednesford	Nov.	2, 1872	
734	Willis, E., Clarence House, Willington, near Durham	Sept.	5, 1868	
735	WILLIS, JAMES, 73, Westmorland Road, Newcastle (<i>Member of Council</i>)	Mar.	5, 1857	
736	Wilmer, F. B., Duffryn Collieries, Aberdare...	...	June	6, 1856
737	Wilson, J., 69, Great Clyde Street, Glasgow	...	July	2, 1872
738	Wilson, J. B., Wingfield Iron Works and Coll., Alfreton	Nov.	5, 1852	
739	Wilson, J. S., Moorfield, Coxlodge, Newcastle-on-Tyne	Dec.	2, 1858	
740	Wilson, Robert, Flimby Colliery, Maryport	...	Aug.	1, 1874
741	Wilson, T. H., 26, Sandhill, Newcastle-on-Tyne	...	Mar.	6, 1869
742	Wilson, W. B., Cannock and Seacroft Collieries, Can- nock, Staffordshire	...	Feb.	6, 1869
743	Winship, J. B., Newcastle, Australia	...	Dec.	4, 1869
744	Winter, T. B., Grey Street, Newcastle-on-Tyne	...	Oct.	7, 1871
745	Wood, C. L., Freeland, Bridge of Earn, Perthshire	...		1853
746	Wood, J., Flockton Collieries, Wakefield	...	April	2, 1863
747	WOOD, LINDSAY, Southill, Chester-le-Street (<i>PRESIDENT</i>)	Oct.	1, 1857	
748	Wood, Thomas, Rainton House, Fence Houses	...	Sept.	3, 1870
749	Wood, W. H., West Hetton, Ferryhill	...		1856
750	Wood, W.O., East Hetton Colliery, Coxhoe, Co. Durham	Nov.	7, 1863	
751	Woodgate, A., Chemical Manure Manfr., Newcastle...	Feb.	3, 1872	
752	Woodhouse, J. T., 3, Westminster Chambers, Victoria Street, Westminster, London, S.W.	...	Dec.	13, 1852
753	Woolcock, Henry, St. Bees, Cumberland	...	Mar.	3, 1873
754	Wright, G. H., Heanor Hall, Heanor, near Derby	...	July	2, 1872

755	Wight, R., Killingworth Colliery, Newcastle	...	Oct.	11, 1873
756	Wrightson, T., Stockton-on-Tees	...	...	Sept. 13, 1873
757	Young, Philip, Deckham Hall Colliery, Gateshead	...	Oct.	11, 1873

Students.

1	Atkinson, F. R., Haswell Colliery, Fence Houses	...	Feb.	14, 1874
2	Atkinson, J. B., Chilton Moor, Fence Houses	...	Mar.	5, 1870
3	Avery, F. S., Killingworth Colliery, Newcastle	...	May	2, 1874
4	Ayton, Henry, Seaton Delaval Colliery, Dudley, Northd.	Mar.	6,	1875
5	Bain, Donald, Seaton Delaval Colliery, Dudley, Northd.	Mar.	3,	1873
6	Barnes, A. W., Grassmore Colliery, near Chesterfield	...	Oct.	5, 1872
7	Barrett, Charles, Harton Colliery, South Shields	...	Nov.	9, 1874
8	Bell, C. E., 31, Old Elvet, Durham	...	Dec.	3, 1870
9	Berkley, R. W., Marley Hill Colliery, Gateshead	...	Feb.	14, 1874
10	Bewick, T. B., Haydon Bridge, Northumberland	...	Mar.	7, 1874
11	Blackie, R., Litherland House, Seaforth, Liverpool	...	Nov.	9, 1874
12	Boyd, R. F., Moor House, near Durham	...	Nov.	6, 1869
13	Bragge, G. S., Nunnery Colliery Offices, Sheffield	...	July	2, 1872
14	Brough, Thomas, Seaham Colliery, Seaham Harbour	...	Feb.	1, 1873
15	Brown, M. W., Hamsteels Colliery, Durham	...	Oct.	7, 1871
16	Bruce, John, Marley Hill Colliery, Gateshead	...	Feb.	14, 1874
17	Bulman, G. H., Haswell Colliery, Fence Houses	...	April	11, 1874
18	Bulman, H. F., Killingworth Colliery, Newcastle	...	May	2, 1874
19	Bunning, C. Z., Neville Cottage, Newcastle-on-Tyne	...	Dec.	6, 1873
20	Burnley, E. F., Hope Cottage, The Common, Normanton	April	11,	1874
21	Burrows, J. S., Medomsley, Newcastle-on-Tyne	...	Oct.	11, 1873
22	Byerley, R. Reed, Houghton-le-Spring	...	Mar.	5, 1870
23	Caldwell, John S., The Grove, Westhoughton, near Bolton Law	...	Nov.	9, 1874
24	Candler, T. E., East Lodge, Crook, Darlington	...	May	1, 1875
25	Chambers, W. Henry, Birchwood Colls., near Alfreton	...	Dec.	2, 1871
26	Clark, R. B., Burnopfield, Lintz Green	...	May	3, 1873
27	Clough, James, Seaton Delaval Colliery, near Newcastle	April	5,	1873

28	Cobbold, C. H., Harton Colliery Office, Tyne Dock, South Shields	...	...	...	...	May	3, 1873
29	Cockburn, W. C., 8, Summerhill Grove, Newcastle	...	...	...	...	July	2, 1872
30	Cockin, G. M., Bishopwearmouth Rectory, Sunderland	...	...	...	...	Nov.	2, 1872
31	Corfield, F. C., Butterly Park, Alfreton	...	...	...	...	Aug.	2, 1873
32	Crone, E. W., Killingworth Hall, near Newcastle	...	...	...	...	Mar.	5, 1870
33	Darlington, J., Springfield, Wigan	...	...	...	...	Nov.	9, 1874
34	Dorman, Frank, Stanley Colliery, Crook	...	...	...	...	May	1, 1875
35	Eden, C. H., Sedgefield, Ferryhill	...	...	...	...	Sept.	13, 1873
36	Edge, J. C., Ince Hall Coal and Cannel Co. Lim., Wigan	...	...	...	...	Dec.	5, 1874
37	Elliot, W. S., Thrislington Colliery, nr. Ferryhill Station	...	...	...	...	Sept.	13, 1873
38	Fletcher, J., Kelton House, Dumfries	...	...	...	...	July	2, 1872
39	Forster, J. T., Washington, Gateshead	...	...	...	...	Aug.	1, 1868
40	Garthwaite, T. Y. B., Greenside, Blaydon-on-Tyne	...	...	...	...	Feb.	1, 1873
41	Gerrard, James, Ince Hall Coal and Cannel Co., Wigan	...	...	...	...	Mar.	3, 1873
42	Greener, T. Y., Pemberton Collieries, near Wigan	...	...	...	...	July	2, 1872
43	Hague, E., Endcliffe Vale, Sheffield	...	...	...	...	Mar.	2, 1872
44	Hallimond, W. T., Etherley Coll., Escomb, Bp. Auckland	...	...	...	...	May	2, 1874
45	Hamilton, E., Rig Wood, Saltburn-by-the-Sea	...	...	...	...	Nov.	1, 1873
46	Harris, W. S., Marley Hill Colliery, Gateshead	...	...	...	...	Feb.	14, 1874
47	Harrison, Robert J., Silksworth Colliery, Sunderland	...	...	...	...	May	1, 1875
48	Heckels, W. J., Wearmouth Colliery, Sunderland	...	...	...	...	May	2, 1868
49	Hedley, E., Rainham Lodge, The Avenue, Beckenham, Kent	...	...	...	...	Dec.	2, 1871
50	Hedley, George	...	...	...	...	Aug.	2, 1873
51	Hodgson, J. W., Dipton Coll., <i>via</i> Lintz Green Station	...	...	...	...	Feb.	5, 1870
52	Hughes, H. E., Bowers Allerton Collieries, Limited, Astley, Woodlesford	...	...	...	...	Nov.	6, 1869
53	Hutton, J. A.,	...	...	...	...	Sept.	4, 1869
54	Jepson, H., Harton Coll. Office, Tyne Docks, So. Shields	...	...	...	...	July	2, 1872
55	Johnson, W., Strangeways Hall, &c., Collieries, Wigan	...	...	...	...	Feb.	14, 1874
56	Jordan, J. J., South Derwent Colliery, <i>via</i> Lintz Green	...	...	...	...	Mar.	3, 1873
57	Leach, C. C., Bedlington Collieries, Bedlington	...	...	...	...	Mar.	7, 1874

- 58 Liddell, J. M., Nedderton, Northumberland ... Mar. 6, 1875
- 59 Lisle, J., Washington Colliery, Co. Durham ... July 2, 1872
- 60 Mann, A. C., Seaham Colliery, Seaham Harbour ... Feb. 6, 1875
- 61 Marsh, T. G., Burnt Tree House, Tipton, Staffordshire Sept. 13, 1873
- 62 Miller, D. S., Wearmouth Colliery, Sunderland ... Nov. 9, 1874
- 63 Mills, M. H., Weardale Iron & Coal Co., Towlaw, Darling-
ton ... Feb. 4, 1871
- 64 Moor, W., jun., Lanelay Coll., Llantrissant, Glam. ... July 2, 1872
- 65 Moore, R. W., Colliery Office, Whitehaven ... Nov. 5, 1870
- 66 Moreing, C. A., Haydon Bridge, Northumberland ... Nov. 9, 1874
- 67 Moses, W., Lumley Colliery, Fence Houses ... Mar. 2, 1872
- 68 Mundle, Arthur, 7, Hawthorn Street, Newcastle ... June 5, 1875
- 69 Mundle, Robert, Redesdale Mines, Bellingham ... Mar. 6, 1875
- 70 Ornsby, R. E., Seaton Delaval Colliery, Dudley, Northd. Mar. 6, 1875
- 71 Pamely, C., Radstock Coal Works, near Bath ... Sept. 5, 1868
- 72 Place, Thomas, Newbottle Land, Houghton-le-Spring,
Fence Houses ... April 2, 1870
- 73 Pocock, Francis A., Silksworth Colliery, Sunderland ... Mar. 6, 1875
- 74 Potter, A. M., Heaton Hall, Newcastle... ... Feb. 3, 1872
- 75 Potter, E. A., Cramlington House, Northumberland ... Feb. 6, 1875
- 76 Prest, J. J., Belmangate, Guisbro' ... May 1, 1875
- 77 Rathbone, Edgar P., Duke of Norfolk's Colliery Offices,
Sheffield ... Mar. 7, 1874
- 78 Ritson, W. A., Wylam Wood Colliery, Wylam-on-Tyne April 2, 1870
- 79 Robson, J. M., 11, Belhaven Terrace, Glasgow ... Dec. 5, 1868
- 80 Sawyer, A. R., Towneley Colliery, Blaydon-on-Tyne ... Dec. 6, 1873
- 81 Scott, C. F., Monk Bretton, near Barnsley ... April 11, 1874
- 82 Short, James T., Assoc. Coll. of P. S., Bedlington Col-
liery, Bedlington ... Dec. 5, 1874
- 83 Southern, E. O., 5, Fenwick Terrace, Jesmond, Newcastle Dec. 5, 1874
- 84 Southern, W. J., Tanfield Lea Colliery, by Lintz Green Aug. 1, 1874
- 85 Stobart, F., Cocken Hall, Fence Houses ... Aug. 2, 1873
- 86 Stones, T. H., Wigan Coal and Iron Co., Wigan ... Nov. 9, 1874
- 87 Telford, W. H., Cramlington Colliery, Northumberland Oct. 3, 1874

88	Thompson, William, Washington Colliery, Co. Durham	May	2,	1874
89	Vernon, J. O., Villa de St. George, Newcastle...	... Sept.	7,	1867
90	Walker, G. B., Osgathorpe, Sheffield	... Dec.	2,	1871
91	Walton, J. C., Heworth Colliery, near Newcastle	... Nov.	9,	1874
92	Williamson, J. E., Harton Colliery Offices, Tyne Docks, South Shields	... Nov.	9,	1874
93	Wilson, J. T., Thornton Fields, Guisbro'	... Nov.	9,	1874

List of Subscribing Collieries.

Owners of Ashington Colliery, Newcastle-on-Tyne.

- „ East Holywell Colliery, Earsdon, Northumberland.
- „ Haswell Colliery, Fence Houses.
- „ Hetton Collieries, Fence Houses.
- „ Lambton Collieries, Fence Houses (Earl Durham).
- „ North Hetton Colliery, Fence Houses.
- „ Rainton Collieries (Marquess of Londonderry).
- „ Ryhope Colliery, near Sunderland.
- „ Seghill Colliery, Northumberland.
- „ South Hetton and Murton Collieries.
- „ Stella Colliery, Hedgefield, Blaydon-on-Tyne.
- „ Throckley Colliery, Newcastle.
- „ Wearmouth Colliery, Sunderland.
- „ Whitworth Colliery, Ferryhill.

Rules.

1.—The objects of the North of England Institute of Mining and Mechanical Engineers are to enable its members to meet together to discuss the means for the Ventilation of Coal and other Mines, the Winning and Working of Collieries and Mines, the Prevention of Accidents, and the advancement of the Sciences of Mining and Engineering generally.

2.—The North of England Institute of Mining and Mechanical Engineers shall consist of three classes of members, namely :—Ordinary Members, Life Members, and Honorary Members, with a class of Students attached.

3.—Ordinary and Life Members shall be persons practising as Mining or Mechanical Engineers, and other persons connected with or interested in Mining and Engineering.

4.—Honorary Members shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society, Government Mining Inspectors during the term of their office, and the Professors of the College of Physical Science, Newcastle-upon-Tyne, during their connection with the said College.

5.—Students shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineers, and such persons may continue Students until they attain the age of 23 years.

6.—The Annual Subscription of each Ordinary Member shall be £2 2s., payable in advance, and the same is to be considered due and payable on the first Saturday of August in each year, or immediately after his election.

7.—All persons who shall at one time make a donation of £20 or upwards shall be Life Members.

8.—The Annual Subscription of each Student shall be £1 1s., payable in advance, and the same is to be considered due and payable on the first Saturday of August in each year, or immediately after his election.

9.—Each Subscriber of £2 2s. annually (not being a Member) shall be entitled to a ticket to admit two persons to the rooms, library, meetings, lectures, and public proceedings of the Society ; and for every additional £2 2s., subscribed annually, two other persons shall be admissible up to the number of ten persons ; and each such Subscriber shall also be entitled for each £2 2s. subscription to have a copy of the Proceedings of the Institute sent to him.

10.—Persons desirous of being admitted into the Institute as Ordinary Members, Life Members, or Students, shall be proposed by three Members, and as Honorary Members by at least five Members. The nomination shall be in writing and signed by the proposers (see Form A), and shall be submitted to the first General or Special Meeting after the date thereof. The name of the person proposed shall be exhibited in the Society's room until the next General or Special Meeting, when the election shall be proceeded with by ballot, unless it be then decided to elect by show of hands. A majority of votes shall determine every election. Notice of election shall be sent to each Member or Student within one week after his election, on Form B, enclosing at the same time Form C, which shall be returned by the Member or Student, signed, and accompanied with the amount of his annual subscription, within two months from the date of such election, which otherwise shall become void.

11.—The Officers of the Institute shall consist of a President, six Vice-Presidents, and eighteen Councillors, who, with the Treasurer and Secretary (if Members of the Institute), shall constitute a Council for the direction and management of the affairs of the Institute. The President, Vice-Presidents, and Councillors shall be elected at the Annual Meeting (except in case of vacancies), and shall be eligible for re-election, with the exception of any President or Vice-President who may have held office for the three immediately preceding years, and such six Councillors who may have attended the fewest Council Meetings during the past year ; but such Members shall be eligible for re-election after being one year out of office.

12.—All Members shall be at liberty to nominate, in writing, and send to the Secretary, not less than fourteen days prior to the Annual or Special Meeting, a list of Ordinary and Life Members who are considered suitable to fill the various offices, such list being signed by the nominators. A list of the persons so nominated and of the retiring Officers, indicating those who are ineligible for re-election (see Form G), shall constitute a balloting list, and shall be posted at least seven days previous to the Annual or Special Meeting, to all Members of the Institute, who may erase any name or names from this list, and substitute the name or names of any other person or persons eligible for each respective office ; but the number of persons on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices as above enumerated. The balloting papers must be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the Meeting, so as to be received before the hour fixed for the election of

Officers. The Chairman shall then appoint four Scrutineers, who shall receive the balloting papers, and shall sign and hand to the Chairman of the Meeting a list of the elected Officers, after destroying the papers. Those papers which do not accord with these directions shall be rejected by the Scrutineers. The votes for any Members who may not be elected Vice-Presidents shall count for them as Members of the Council.

In case of the decease or resignation of any Officer or Officers, notice thereof shall be given at the next General or Special Meeting, and a new Officer or Officers elected at the succeeding General or Special Meeting, in accordance with the mode above indicated.

13.—At meetings of the Council, five shall be a quorum, and the minutes of the Council's proceedings shall be at all times open to the inspection of the Members of the Institute. The President shall be *ex-officio* Chairman of every Committee.

14.—All Past-Presidents shall be *ex-officio* Members of the Council so long as they continue Members of the Institute, and Vice-Presidents who become ineligible from having held office for three consecutive years shall be *ex-officio* Members of the Council for the following year.

15.—A General Meeting of the Institute shall be held on the first Saturday of every month (except January and July) at two o'clock ; and the General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year, shall be presented by the Council. A Special Meeting of the Institute shall be called whenever the Council may think fit, and also on a requisition to the Council, signed by ten or more Members.

16.—Every question, not otherwise provided for, which shall come before any Meeting of the Institute, shall be decided by the votes of the majority of the Ordinary or Life Members then present.

17.—The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be disbursed or invested by him according to the direction of the Council.

18.—All papers shall be sent for the approval of the Council at least twelve days before a General Meeting, and after approval shall be read before the Institute. The Council shall also direct whether any Paper read before the Institute shall be printed in the Transactions, and notice shall be given to the writer within one month after it has been read, whether it is to be printed or not.

19.—The Copyright of all Papers communicated to, and accepted for printing by the Council, shall become vested in the Institute, and such

communication shall not be published for sale or otherwise, without the written permission of the Council.

20.—All proofs of discussion, forwarded to Members for correction, must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

21.—The Institute is not, as a body, responsible for the facts and opinions advanced in the Papers which may be read, nor in the discussions which may take place at the Meetings of the Institute.

22.—Twelve copies of each Paper printed by the Institute shall be presented to the author for private use.

23.—Members elected at any Meeting between the Annual Meetings shall be entitled to all Papers issued in that year, as soon as they have signed and returned Form C, and paid their subscriptions.

24.—The Transactions of the Institute shall not be forwarded to Members whose subscriptions are more than one year in arrear.

25.—Any person whose subscription is two years in arrear, that is to say, whose arrears and current subscriptions shall not have been paid on or before the first of August, shall be reported to the Council, who shall direct application to be made for it according to form D, and in the event of it continuing one month in arrear after such application, the Council shall have the power, after suitable remonstrance by letter in the form so provided (Form E), of erasing the name of the defaulter from the register of the Institute.

26.—No duplicate copies of any portion of the Transactions shall be issued to any of the Members unless by written order from the Council.

27.—Invitations shall be forwarded by the Secretary to any gentleman whose presence at the discussions the Council may think advisable, and strangers so invited shall be permitted to take part in the proceedings. Any Member of the Institute shall also have power to introduce two strangers (see Form F) to any of the General Meetings of the Institute, but they shall not take part in the proceedings except by permission of the Meeting.

28.—No alteration shall be made in any of the Laws, Rules, or Regulations of the Institute, except at the Annual General Meeting, or at a Special Meeting for that purpose, and the particulars of every such alteration shall be announced at a previous General Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of, or addition to, the Rules.

[FORM A.]

being desirous of admission into the North of England Institute of Mining and Mechanical Engineers, we, the undersigned, propose and recommend that he shall become a thereof.

Proposed by } _____ } Signatures
 _____ } of three
 _____ } Members.

18

[FORM B.]

SIR,—I beg to inform you that on the _____ day of _____ you were elected a _____ of the North of England Institute of Mining and Mechanical Engineers, but in conformity with its Rules your election cannot be confirmed until the enclosed form be returned to me with your signature, and until your first annual subscription be paid, the amount of which is £ _____

If the first subscription is not received within two months from the present date, the election will become void under Rule 10.

I am, Sir,

Yours faithfully,

Secretary.

18

[FORM C.]

I, the undersigned, being elected a _____ of the North of England Institute of Mining and Mechanical Engineers, do hereby agree that I will be governed by the regulations of the said Institute as they are now formed, or as they may hereafter be altered; that I will advance the objects of the Institute as far as shall be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the Meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) be free from this obligation.

Witness my hand this

day of

18

(1)

[FORM D.]

18

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to draw your attention to Rule 25, and to remind you that the sum of £ of your annual subscriptions to the funds of the Institute remains unpaid, and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Rule above referred to.

I am, Sir,

Yours faithfully,

Secretary.

[FORM E.]

18

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you, that in consequence of non-payment of your arrears of subscription, and in pursuance of Rule 25, the Council have declared, by special vote, on the day of 18 , that you have forfeited your claim to belong to the Institute, and your name will be in consequence expunged from the Register, unless payment is made previous to

But notwithstanding such forfeiture, I am directed to call upon you for payment of your arrears, amounting to £

I am, Sir,

Yours faithfully,

Secretary.

[FORM F.]

Admit
of

to the Meeting on Saturday, the
(Signature of Member or Student)

The Chair to be taken at Two o'clock.

I undertake to abide by the Regulations of the North of England Institute of Mining and Mechanical Engineers, and not to aid in any unauthorised publication of the Proceedings.

(Signature of Visitor)

Not transferable.

[FORM G.]

BALLOTING LIST.

Ballot to take place at the Meeting of _____ 18 _____ at Two o'Clock.

PRESIDENT—One Name to be returned.

† _____ Retiring President.

* { _____
_____ } New Nominations.

VICE-PRESIDENTS—Six Names to be returned.

The Votes for any Members who may not be elected as Vice-Presidents will count for them as other Members of the Council.

† { _____

_____ } Retiring Vice-Presidents.

* { _____
_____ } New Nominations.

COUNCIL—Eighteen Names to be returned.

† { _____

_____ } Retiring Councillors.

* { _____

_____ } New Nominations.

Rule XII.—Relative to the Election of the Officers of the Institute.

† These Gentlemen are ineligible for re-election.

* These Gentlemen are not on the Council for the present year.

Names substituted for any of the above are to be written in the blank spaces opposite those they are intended to supersede.

Any List returned with a GREATER NUMBER than
ONE PRESIDENT,

SIX VICE-PRESIDENTS,
EIGHTEEN COUNCILLORS,

Will be rejected by the Scrutineers as informal, and the Votes will, consequently, be lost.

NORTH OF ENGLAND INSTITUTE
OF
MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING, AUGUST 5TH, 1874, AT THE CARDIFF ARMS,
CARDIFF.

MR. W. COCHRANE, VICE-PRESIDENT IN THE CHAIR.

The proceedings of to-day comprised the reading of papers by Mr. Wallace, on "The Warsop Rock Drill;" Mr. J. B. Simpson, on "The Coal-Fields and Mining Industries of Russia;" Messrs. Daglish and Howse, on "The North Lincolnshire Ironstone Field;" and Mr. Walker, on "A New Hook for preventing Overwinding;" and the discussions thereon. After which, the Secretary completed the reading of Mr. Brown's paper on "The South Wales Coal-Field." Mr. Brown's and Mr. Wallace's papers have been published in the last Volume; and Mr. Simpson's paper, on "The Coal-Fields and Mining Industries of Russia," forms the commencement of Volume XXIV.

ON THE COAL-FIELDS AND MINING INDUSTRIES OF RUSSIA.

BY JOHN BELL SIMPSON.

THE writer having recently visited Russia and collected information and statistics relative to the mining industry of this great country, has thought that some remarks thereon might not be uninteresting to the members, especially as there appears to have been so little published on the subject.

I.—GEOLOGICAL KNOWLEDGE OF THE COUNTRY.

As far back as 1848, Sir R. Murchison, Edward de Verneuil and Count Keyserling, made a geological survey of Russia under the auspices of the Imperial Government, and produced an elaborate and valuable description of the same, together with a detailed geological map. Since then, several observers have been at work and have made more detailed examinations of the different districts. Among these we may mention General Helmersen, Valerian de Moller and Captain A. Antipoff. These further explorations have, as was to be expected, rendered considerable modifications necessary in the original map, but it has, nevertheless, served as the basis of all that have since been published. The Government Administration of Mines, it may be mentioned, is now contemplating, and has almost decided upon, a geological survey similar to that of the United Kingdom.

From what is to be seen at St. Petersburg it is quite evident that the Government is fully alive to the importance of the study of geology, and already there are no fewer than 300 pupils attending the course of instruction given by the Corps des Mines, where there are two chairs—one for mining, and the other for manufactures. There are also mining schools at Ekaterinbourg, Barynaoul, and Lisitschansk.

The museum of St. Petersburg, if judged by the variety and value of its mineral specimens, is, probably, not surpassed in any country. A visitor to it is at once led to feel that this country must be exceedingly rich in minerals, and certainly a personal survey of any of the districts through which the writer passed does not tend to alter this opinion.

From the geological map of General Helmersen, from which Plate I. has been reduced, it will be seen that the carboniferous limestone formation has a very extensive range. It appears south of Moscow, occupying an enormous area, and extending northwards in considerable breadth to the White Sea. Thin bands of it also flank both sides of the Ural Mountains at intervals. It again occurs over an extensive area in the Donetz district near the Black Sea. Sir Roderick Murchison says that—"The upper member of this system, which is so copiously developed in Western Europe under the name of the coal measures and terrain houiller, has not any decided representation in Russia," and it would appear from present knowledge of the subject, that the chief coal-fields of Central Russia and of the Donetz belong to the lower carboniferous series, having their parallel in point of age in the Scremerston Coal-field near Berwick, and the lower coal series of Scotland. The coal-field of Poland, on the other hand, is supposed to belong to the upper or regular coal measures.

It will also be observed from the map that the Permian formation occurs over an immense tract of Central Russia, and there is a reasonable probability that seams of coal may one day be found at workable depths over large areas under these more recent deposits. In fact the coal-bearing strata are already known to pass under cretaceous rocks in the Donetz district; but the writer is not aware of any attempt having been made to sink or bore through the Permian beds in Russia to prove the existence or non-existence of coal measures underneath.

II.—DESCRIPTION OF THE COAL-FIELDS AT PRESENT BEING WORKED.

The following are the most important coal-mining districts now in operation, viz. :—

1. Central Russian or Moscow Coal-Field.
2. Donetz and territory of the Don Cossacks, near the Black Sea, or South Russian Coal-Field.
3. Ural Mountains.
4. Poland.

1.—CENTRAL RUSSIAN OR MOSCOW COAL-FIELD.

In this district the coal-bearing strata extend over a great area, probably about 13,000 square miles. At present there are a few collieries at work, but only in a limited way, their total output scarcely reaching 140,000 tons per annum. Many explorations have been made in other places, in positions marked on Plate II., but the writer has been unable to

get much information respecting them. Absence of demand, and the great distance from the railway system of the country has hitherto no doubt operated against their development, but now that lines of railway are being made across the district, collieries will be gradually opened out. Several seams have been found, but, generally, it may be said that there are two workable seams in this district lying near each other, and only a short distance above the Devonian or old red sandstone.

At Towarkowo, about 150 miles south of Moscow, the following is a section of the strata :—

- 1.—Soil.
- 2.—Loam.
- 3.—Yellow clay.
- 4.—Gray sand.
- 5.—Hard stratified mountain limestone.
- 6.—Gray clayey sand.
- 7.—Quicksand.
- 8.—Coal, 3 feet 6 inches.
- 9.—Blue clay.
- 10.—Coal, 7 feet—chief coal seam.
- 11.—Gray clay.
- 12.—Devonian formation.

There are not many large faults, but the coal being near the surface, and having in many instances no covering of rock, has its continuity occasionally interrupted by denudation. This will be seen from the accompanying sections of the district, Plates III. and IV., reduced from that given by Mons. Emil Leo, in an interesting and valuable work, “*Die Steinkohlen Central Russlands*,” which illustrate the irregular and undulating character of the seams.

The following is a section of a pit in the Tchulkovo district, about 180 miles south of Moscow, which the writer visited in May last.

Loose sand and semi-solidified sandstone, about 10 fathoms.						
Coal	...	...	...	...	...	5 ft. 6 in. to 7 ft.
Stone	...	...	...	...	...	6 ft.
Coal	...	...	...	...	...	3 ft.

The soft nature of the beds immediately above the upper coal, which is the one now being worked, necessitates a large amount of timbering. In this case the seams were lying nearly horizontal, but often varied in thickness. This colliery is the largest in the district, and is working at the rate of about 50,000 tons per annum, and Plate V. is a sketch of the exterior of the colliery. The pits are seldom more than 10 or 12 fathoms

deep. They are little troubled with either water or fire-damp. The shafts are generally rectangular in form, and the produce is sometimes raised by horses, and in other cases by means of small steam-engines of 8 to 10 horse-power.

The system of working the coal is a very good one, being that generally known as the block system, or modification of bord and pillar. The pillars are left about 20 yards square, and after a time are worked off. Tubs of the ordinary kind are used, and carry about 6 cwt. of coal. The shafts are fitted with guides and cages, wire ropes being used for raising the load. Altogether the arrangements for bringing the coal to bank are better than might have been expected.

In the methods of hewing and putting, however, there is much room for improvement. Three men generally work together in a place. The coal is forced from its bed, not with picks and by blasting, but by means of a crowbar, which is about 4 feet 6 inches in length and $1\frac{1}{2}$ inches in thickness. This implement two of the men drive into the mass of coal by striking repeatedly near the same spot. By this means they manage to bring down pretty large pieces. When the tub or wagon has been filled, the third man takes it away to the shaft, whatever distance this may be. The application of picks and blasting to loosen the coal, and the introduction of horses and ponies to haul it to the shaft, are improvements which time will no doubt effect. The men work long hours, commencing at 6 a.m. and leaving off at 6 p.m., with an intermission of an hour in the middle of the day, when they come to bank for dinner.

The wages of the different classes of labour in this district are as follows :—

Hewers	10d. per ton, including putting to the shaft, making them an average of	...	...	...	...	1s. 8d. per day.
Smiths	...	...	...	...	...	1s. 4d. to 1s. 7d. „
Carpenters	...	...	...	...	...	1s. 1d. to 1s. 7d. „
Enginemen	...	...	...	...	...	2s. 0d. „
Firemen	...	...	...	...	...	1s. 5d. „
Banksmen	...	...	...	...	...	1s. 6d. „
Labourers	...	...	...	...	...	9½d. to 1s. 1d. „

These wages are rather like what was paid in the Newcastle district in olden times, when an old chronicler states, “that horses were £6 or £7 each; score price 10d. to 1s. for 15 peck corves, or about 2½d. per ton; shift work 1s. per day; overman’s wages 8s. per week; and lastly, the viewer well deserves his 15s. or 16s. per week, if he has care and parts.”

The men generally live at a great distance from the pits, and go to

their homes only occasionally, chiefly at Easter, when there is a fortnight's holiday. At the mines there are lodging-houses, which contain perhaps 100 men in one place, not a very comfortable manner of living, but doubtless in course of time improved dwellings will be necessary to insure a better class of workmen. The men seem industrious and exceedingly civil. They are considered not very ingenious, but very willing and apt in carrying out the wishes of those over them.

With respect to the quality of this coal, as compared with English coal, it is very impure and pyritous, and has all the appearance of what may be termed a good lignite. Occasionally occurring in this bed of coal is a band or layer about an inch thick, of what is called in Germany "paper coal." This consists of vegetable matter, probably lepidodendron, with its original structure wonderfully preserved. The following are analyses of samples of coal from several localities :—

Carbon	...	...	...	59.75	68.04	60.48	48.01
Hydrogen	...	...	...	5.12	9.06	6.27	5.63
Nitrogen	...	...	...	.80	1.64	.63	1.06
Oxygen	...	...	...	14.73	11.13	19.49	26.56
Sulphur	...	...	...	5.15	2.11	1.89	2.31
Ash	...	...	...	14.74	8.02	11.24	16.43
				100.29	100.00	100.00	100.00

The average of 35 analyses of coal, given by Monsieur Leo, gives 18 per cent. of ash.

In locomotives, as also in some of the sugar and other manufactories, this coal is coming into partial use, but at present wherever wood (which comes to nearly the same price as coal in this locality) can be obtained, it is always preferred.

As to the occurrence of coal northward of Moscow, in the carboniferous limestone formation, it is stated that very thin seams have been found, but it is believed that in this, as in many other districts, there has not yet been anything worthy of being called a thorough exploration. This coal-field, situated as it is in a region where the price of wood is rapidly rising, and through which railways are either in course of construction or projected, will no doubt shortly prove to be of fresh value to Central Russia.

Monsieur Leo, in the work previously referred to, gives a list of the fossils found in the carboniferous limestones and associated coal beds, from which it will be seen that a similar class of remains have been found as those in the same formation in England.

Calamites are rare, as also seeds and fruits. Ferns are found in enormous quantities and endless varieties.

2.—THE DONETZ OR SOUTH RUSSIAN COAL-FIELD.

In this district, the carboniferous formation extends, it is said, over an area of at least 11,000 square miles, or 11 times the area of the great Welsh coal-field. More recent calculations put the area at a much higher figure. It contains numerous seams of coal, some of which are much superior in quality to that of the Central Russian district. This coal-field is the one most extensively-worked at present, and possessed of great advantages in the way of railway communication, and in its proximity to sea ports.

Dislocations of the strata are of somewhat frequent occurrence, in consequence of which and of the undulating nature of the country, coal has been brought to the surface in many places; but, on the other hand, the angle of dip being sometimes high, the beds soon attain considerable depth. In this region, anthracite coal is found as well as bituminous, the seams which are bituminous in one district becoming anthracite in another. In regard to this, Sir R. Murchison says, "this phenomenon is analogous to that which exists in the South Wales coal-field, where at one extremity of the tract anthracite coal prevails almost exclusively in beds of precisely the same age as those which bear bituminous coal a little distance to the east. In the Russian example, indeed, we see the mineral character of the coal beds change gradually as we follow them from west to east."

Mr. T. Forster Brown, of Cardiff, has furnished the writer with the following information, which he obtained recently. He says:—"There are sixty seams of coal found in this district, of which forty-four are workable, and represent a total thickness of about 114 feet. The best seams are about 3 feet 6 inches, 3 feet 7 inches, and 5 feet 7 inches in thickness. The average depth of pits is from 50 to 80 yards. The following is said to be an analysis of a fair sample of Khartsisk coal:—

Carbon	...	...	...	...	...	...	...	89.74
Hydrogen	...	...	...	...	...	...	...	3.66
Nitrogen	...	...	...	...	...	...	...	.31
Sulphur	...	...	...	...	...	...	...	1.25
Oxygen	...	...	...	...	...	...	...	2.84
Ash	...	...	...	...	...	...	...	2.20
								<hr/> 100.00

And this may be taken as a general example of the anthracite of this coal-field.

The price of labour varies much. When hired, as is customary, for several months, a collier receives about 1s. 3d. per day of 12 hours, and has good lodgings furnished him. In case, however, of casual engagements, he receives 1s. 6d. per day.

The coal is carried to the railway from some of the pits in carts or sledges, and in some cases as far as 80 miles, on the backs of oxen."

The most valuable part of the Donetz district is said to be at Lugan and Lissitchia Balka, at which latter place, in a vertical depth of about 900 feet, there is an aggregate thickness of 30 feet of coal.

At Grouschewka, which is rather an extensive colliery, there are two seams of coal—one 30 inches, at a depth of 37 fathoms, and another 36 inches, at a depth of 48 fathoms. In 1871 the Donetz district supplied 330,018 tons of coal.

The Coal Commission state that, in the year 1865, the Donetz district worked 6,350,000 tons. This is evidently an error, and should be pounds instead of tons. (A pound is about 36 lbs.) Thus corrected, the report would give the year's yield at 100,000 tons.

In the course of the present year (1874), contracts for the supply of this coal to the extent of many thousand tons were offered for delivery at Taganrog; and it is doubtful whether these were, or are soon likely to be, at such a price as to supersede the over-sea supply from England. In time, no doubt, especially if cheap labour can be secured in any great quantity and the railway facilities continue at anything like the present rate of development, South Russian coal will command the trade of the Black Sea, and even that of the eastern shore of the Mediterranean. Looking at the general interest of the world's commerce, this relief of the strain on the English coal market will be a decided advantage.

3.—URAL COAL-FIELD.

The carboniferous formation extends in a narrow strip along the eastern and western sides of the Ural Mountains over a length of about 1000 miles (Plate VI.). The strata generally dip at a high angle towards the west, and soon become concealed beneath the Permian formation. Sir R. Murchison is of opinion that the coals in the Ural district are of more recent age than the lower carboniferous limestone, and that coal is never found here subordinate to or below the limestone.

Mr. J. W. Marley, of Darlington, who visited this district in 1872, has kindly furnished me with some notes on a productive part of this range of carboniferous rocks between the latitudes 58° and 60°. The fol-

lowing is a section of this formation in the neighbourhood of Lithwinsk and Kiselowski, between Permian rocks above and Devonian beneath :—

- 1.—Fusilina limestone, principal characteristic *Fusilina cylindrica*.
- 2.—Quartzose slate and quartz rock, sometimes with ordinary red and white sandstones unstratified.
- 3.—Coal.
- 4.—Sandstone, with *Stigmaria*, sometimes containing shale beds, and very often coarse conglomerate.
- 5.—Shale, grey to black in colour.
- 6.—Limestone, thin bedded with *spirifer mosquensis*.
- 7.—Shale, black, cherty, with iron pyrites.
- 8.—Limestone, thick bedded and dark, with *Productus Giganteus*.
- 9.—Lower quartzose sandstone, shales and limestone.

Coal has been worked by means of both drifts and shafts in this neighbourhood for a considerable time.

A few miles west of Lithwinsk a large coal-field has been opened up, from which the iron works at Alexandrowski are supplied with fuel. The coal is won both by drifts and shafts, the deepest of the latter being 180 yards. The seams worked in this locality are of considerable thickness. Mr. Marley was informed by Herr Grau, the chief director for the proprietors of the Alexandrowski works, that three seams were being worked at the time of his visit, one of which was 32 feet, one 42 feet, and one 31 feet in thickness, and that in the 42 feet seam there were only two small bands, the remainder being clean coal. The inclination of the seams is from 12° to 18° eastward. Analyses showed the coal to contain about 15 per cent. of ash, 5 per cent. of sulphur, and 65 to 70 per cent. of carbon. The coal is a good, bright, glazy coal, and is used for the boilers and puddling furnaces, as also for household purposes, in the district. A portion of one of the seams is coked in small ovens, and makes a fair, useful article.

At Kiselowski, further south, is a coal of slatey appearance, and containing 30 per cent. of ash. It is used for boiler purposes at the iron and coal mines of the district, for general furnace work, and even for puddling. On the eastern slope, where the dip is about 80°, two seams are worked 3½ feet and 5 feet thick respectively. On the western slope, about a mile distant, these seams are each 7 feet thick, the intervening strata being of the same thickness in both cases, viz., 14 yards. A 2 feet seam also was found fourteen feet below the 7 feet seams.

Coal is again worked near Gabucha, fifteen miles south of Kiselowski, on both sides of the anticlinal axis, by means of drifts from the river side.

On the eastern slope the inclination of the strata is about 41° , and the section near the outcrop is as follows :—

								Ft.	In.
White sandstone	...	...	...	...	...	...	...	0	0
Shale and sandstone	...	...	...	...	...	...	...	2	11
Coal...	...	...	...	...	...	...	...	5	2
Shale and sandstone	...	...	...	...	...	...	...	8	0
Coal...	...	...	...	...	...	...	...	8	0
White sandstone	...	...	...	...	...	...	...	4	7
Coal...	...	...	...	...	...	...	...	3	5
Shale and sandstone	...	...	...	...	...	...	...	4	10
Coal...	...	...	...	...	...	...	...	4	3

Making an aggregate thickness of more than 20 feet of coal. This coal is soft and friable, but burns with great heat. It contains a considerable quantity of ash, but very little stone. On the western slope, five or six miles from Gabucha, the beds have an inclination of 45° to the west, and the following is said to be the section :—

Slatey coal	...	...	...	...	...	2 ft. 4 in.
Coal	...	...	...	...	...	7 „ 0 „
Sandstone	...	...	...	...	...	2 „ 4 „
Coal	...	...	...	...	...	7 „ 0 „
Shale	...	...	...	...	...	33 „ 0 „
Coal	...	...	...	...	...	2 „ 8 „

Sir R. Murchison mentions two seams of coal, one of middling quality and about 3 feet thick, as occurring in the Tchussovaya district. Here the limestones and accompanying strata are not less than 1,000 feet thick, and dip towards the west at an angle of 70° . Some of the beds contain *spirifer mosquensis* which unquestionably refers them to the white limestone of Moscow. The limestone beds are overlaid, surmounted by millstone grit, and the beds of coal are subordinate to this latter formation. Mr. Marley states that convicts work in some of the mines of the Ural district, as also women, and that in 1872 the workmen received from 1s. 2d. to 1s. 5d. per day.

The quantity of coal worked in this district is about 13,425 tons.

This coal-field will, no doubt, rapidly increase in importance when the projected railway to Perm is completed.

4.—COAL-FIELD OF POLAND.

This coal-field, as has been already remarked, differs from those of Central Russia and the Donetz, since it belongs to the upper or true coal measures. The writer is indebted to Mr. T. J. Bewick, of Haydon Bridge, for the following notes, and also for the map having reference to it, Plate VII.

This coal-field is merely an extension of that of Upper Silesia. It is about 80 square miles in area, but is partially obscured by a thin development of upper Buntersandstein and Muschelkalk, which overlies some portions of it.

There are not less than nine seams of coal of something like the following thicknesses, beginning with the uppermost :—

- 1.— 6 ft. 11 in., but in places much less.
- 2.— 3 „ 6 „ to 6 ft. 3 in.
- 3.— 3 „ 8 „ to 6 „ 2 „, but sometimes thin.
- 4.— 3 „ 2 „ to 3 „ 9 „
- 5.— 5 „ 0 „ to 5 „ 6 „
- 6.— 3 „ 3 „ to 5 „ 0 „
- 7.— 4 „ 1 „ to 6 „ 3 „
- 8.— 6 „ 6 „ but in one place believed to be from 9 ft. to 11 ft.
- 9.—20 „ 0 „ to 21 ft.

The lowest seam is free from band, but some of the other seams have one or more bands in them, of a few inches in thickness.

All the seams do not occur together, except over a small portion of the centre of the basin, where they make up an aggregate thickness of about 60 feet of workable coal. The strata associated with the coals are shales and whitish fine-grained sandstone, and the coal measures are believed to rest on the Devonian formation. The quantity of ash in the coal varies from 1·9 to 14 per cent., whilst the amount of sulphur varies from ·82 to 6·40. In 1871, the output of this district was 296,940 tons.

The following is a list of the wages paid :—

Hewers	... ..	2s. 7d.	per day of 10 hours of actual work.	
Putters	... ..	2s. 0d.	do.	do.
Women and girls,	1s. 3d. to 1s. 5d.	per day	do.	
Fitters	... ..	3s. 5d. to 4s. 3d.	do.	do.
Blacksmiths	... ..	2s. 7d.	do.	do.
Joiners	... ..	2s. 7d.	do.	do.
Masons	... ..	2s. 3d. to 2s. 10d.	do.	do.
Enginemen...	} £3 10s. 10d. per month, or about 2s. 4d. per day.			
Brakesmen...				

Hours of
Work, Winter
and Summer,
6 A.M. to 6
P.M. Sinkers
and other
Workmen
have 8 hours.

Enginemen and brakesmen have house-rent free and are found with coal. All others pay a nominal rent for their houses, but have to keep them in repair. For the most part all the workpeople have coal free, but have to seek it from the pits.

III.—OTHER COAL FIELDS.

There are several other districts in which coal is being worked on a small scale, viz :—In the Caucasus, at Kief Elizabethgrad, in Tourkestan, in the island of Sagalin (formerly belonging to Japan), and in Siberia, but the author regrets that he has no detailed information respecting them.

Dr. Peez and J. Pecker, in their Report of the Vienna Exhibition, state that the Siberian coal basin, on the northern slope of the Altai Mountains, in the government of Tomsk, is probably the largest coal-field in the world, and possesses seams of greater thickness and good quality.

Before leaving this part of the subject, it may be interesting to advert to the phenomenon of distinct classes of coal co-existing in one and the same bed, or being found in beds of the same age. For instance, in the Moscow or Tula field, as also in the Donetz district, there are really three distinct kinds of coal—lignite, bituminous and anthracite. How such difference of texture, density, and even composition are to be accounted for, is still an unsolved problem. Several hypotheses have been advanced in aid of the desired solution. In the first place, it has been suggested that differences in the vegetation prevailing over particular portions of the area subsequently submerged, might account for the differences now observed in the coal. Another supposition is, that the variable thickness and texture of the overlying strata may have effected the rate and extent of the escape of gas during the carbonization of the vegetation beneath. A third theory attributes the phenomenon to the inequality of the heat by which the gases were evolved.

IV.—STATISTICS RELATING TO THE PRODUCTION AND CONSUMPTION OF COAL IN RUSSIA.

From the statistical tables published by the Department of Mines at St. Petersburg, and edited by C. Skalkovsky (*Tableaux Statistiques de L'Industrie des Mines en Russie, 1871*), it appears that the rate of production since coal was first raised in this country has been as follows :—

							Tons.
1830	...	...	...	...	...	...	.....
1840	...	...	...	...	...	...	8,064
1850	...	...	...	...	...	...	48,366
1860	...	...	...	...	...	...	129,032
1868	...	...	...	...	...	...	444,067
1870	...	...	...	...	...	...	697,267
1871	...	...	...	...	...	...	817,008

During 1871, the different districts contributed as follows :—

14 COAL-FIELDS AND MINING INDUSTRIES OF RUSSIA.

							Tons.
1.—	Moscow or Central Russian district	...	...	...	...	...	139,958
2.—	Kief Elisabethgrad	...	...	...	...	...	16,129
3.—	Donetz district (Southern Russia)	...	...	...	...	...	330,019
4.—	Ural	...	...	...	...	...	13,426
5.—	Poland	...	...	...	...	...	296,940
6.—	Basin of Tomsk	...	...	...	...	...	3,677
7.—	Territory of the Kirgheses of Siberia	...	...	...	...	...	7,765
8.—	Sea coasts of Siberia	...	...	...	...	...	4,772
9.—	Basin of the Caucasus	...	...	...	...	...	3,112
10.—	Do. Tourkestan	...	...	...	...	...	1,210
Total							817,008

Of which quantity 28 per cent. is said to be anthracite, and obtained from the Donetz district.

From the latter table it will be seen that the production of Poland amounts to a quarter of the whole, and from the former that although the total production throughout Russia is still very limited, yet during the eleven years ending 1871, it increased about seven-fold.

In regard to the quantity of coal imported into Russia, the Royal Coal Commission Returns provide us with the following account of the imports from England :—

							Tons.
1856	...	...	...	...	...	...	213,553
1860	...	...	...	...	...	...	327,282
1865	...	...	...	...	...	...	465,989
1870	...	...	...	...	...	...	761,781
1871	...	...	...	...	...	...	872,588

There are also some imports from Germany and Belgium, which the returns issued by the Government put at about 227,412 tons, making a total of imported coal of about 1,100,000 tons. In 1872, Russia actually exported 4,400 tons, but the returns for 1871 are not yet to hand. Probably these relate to the South Russia coal-field—the Donetz. If we add the quantity worked in Russia to that imported, and deduct 4,000 tons for estimated exports, we have for 1871 a total of 1,913,000 tons of coal actually available for home use. This is about the same as the produce of England in the year 1660, which the Coal Commission estimated at 2,148,000 tons. Comparing the quantities of coal consumed in Great Britain and Russia, with their respective populations, we have:—

							Population.		Home consumption of Coal.		Rate per head of Population.
									Tons.		Tons. Cwts.
Great Britain	...	...	31,000,000	...	...	105,152,008	...	3	7		
Russia	...	...	76,000,000	...	...	1,917,000	...	0	½		

The abundance and cheapness of wood fuel in Russia has hitherto rendered the working of coal a matter of secondary importance. With a people so progressive as Russians, however, time alone is required to reverse this order of things.

The establishment of manufactories, and the construction of lines of railway worked by locomotive engines, together with the increasing development of the iron trade, which will be more particularly adverted to presently, has occasioned an enormously increased drain upon the wood resources of the country. In some districts, especially in Central Russia, scarcity is already beginning to be felt, and prices are said to be increasing at the rate of about 10 per cent. per annum. The railways actually at work in Russia are of no less an extent than 10,000 miles. Their progress since their introduction is as follows :—

							Miles.
1838	...	...	...	...	...	...	16
1850	...	...	...	...	...	...	308
1860	...	...	...	...	...	...	980
1865	...	...	...	...	...	...	2,429
1868	...	...	...	...	...	...	4,332
1872	...	...	...	...	...	...	9,022
1873	...	...	...	...	...	...	9,900

The lines for the construction of which Government sanction has already been obtained will bring the total mileage up to about 12,000, while many other lines of great length are projected. When the fact of the enormous quantity of fuel necessary to work these railways is considered with the facilities which lines of railway supply to coal-working, it must be evident that this branch of trade in Russia must soon become of prominent importance. The railways of Great Britain are about 15,000 miles in extent, and they consume for locomotives, &c., about two millions of tons per annum. Considerable pressure is no doubt invariably required to alter the customs and overcome the prejudices of any people, but it seems safe to predict that coal must soon take the place of wood as fuel, and, once fairly introduced, its development will doubtless advance with rapid strides.

V.—OTHER MINERAL PRODUCTIONS OF THE COUNTRY.

From the Government Returns we find that the progress in ironstone mining has been as marked as in coal mining ; indeed the rise of both industries must have been nearly simultaneous, and the rate of extension is at several stages notably similar, as will be seen on comparing the

16 COAL-FIELDS AND MINING INDUSTRIES OF RUSSIA.

table already given for coal with that now given for ironstone, which is as follows :—

									Tons.
1830	...	...	...	...	...	...	...	...	—
1840	...	...	...	...	...	...	...	...	112,419
1850	...	...	...	...	...	...	...	...	161,282
1860	...	...	...	...	...	...	...	...	180,768
1868	...	...	...	...	...	...	...	...	651,452
1870	...	...	...	...	...	...	...	...	786,502
1871	...	...	...	...	...	...	...	...	819,736

It will also be seen that an immense increase took place, both in coal and iron, shortly after the Crimean War.

In 1871 different districts contributed as follows :—

									Tons.
Poland	...	...	...	...	...	...	...	...	104,879
Ural	...	...	...	...	...	...	...	...	437,008
Finland	...	...	...	...	...	...	...	...	40,689
Moscow	...	...	...	...	...	...	...	...	135,192
Caucasus	...	...	...	...	...	...	...	...	866
Siberia	...	...	...	...	...	...	...	...	8,692
Sundry places	...	...	...	...	...	...	...	...	22,105
Crown mines	...	...	...	...	...	...	...	...	70,305
									819,736

The writer regrets that he is unable to give any details as to the geological formations in which this ironstone is found, but he may say that it is the general opinion of persons competent to judge that in the Ural Mountains, and in the northern part of Russia, there are immense deposits of ironstone, both of magnetic and other good qualities, which in due time will be largely developed.

The following is a statement of the total mineral production of Russia in 1871 compared with that of Great Britain :—

									Russia. Tons.							Great Britain. Tons.
Lead	...	...	...	...	...	...	...	...	34,514	...	...	...	...	...	...	93,965
Copper	...	...	...	...	...	...	...	...	100,367	...	...	...	...	...	...	97,129
Cobalt	...	...	...	...	...	...	...	...	10	...	...	...	...	...	...	3
Tin	...	...	...	...	...	...	...	...	369	...	...	...	...	...	...	16,272
Zinc	...	...	...	...	...	...	...	...	42,411	...	...	...	...	...	...	17,736
Gold	...	...	...	...	...	...	...	...	38.7	...	...	...	...	...	...	—
Platinum	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	—
Salt	...	...	...	...	...	...	...	...	455,718	...	...	...	...	...	...	1,505,725
Iron	...	...	...	...	...	...	...	...	819,736	...	...	...	...	...	...	16,334,888
Coal	...	...	...	...	...	...	...	...	817,008	...	...	...	...	...	...	117,352,028

From these figures it will be observed that in some branches of mining enterprise Russia will compare favourably with other countries, and it may be stated that the gold washings of Siberia are almost as extensive as anything that is going on in either California or Australia.

It may not be uninteresting to add that in connection with the mines of the country there are employed about 515 steam engines, representing 14,477 H.P., and that there are 2,224 water wheels, representing 39,938 H.P.; also, that in the mining industry of the country there are employed the following persons :—

Mines and manufactures	...	...	...	...	158,446
Gold washings...	...	...	...	...	40,000
In connection with salt works	...	...	...	...	67,854
Total					266,300

From what has been said it will be seen that the coal and iron trades of Russia are still in their infancy, reminding us in many points of the early history of the same trades in this country.

At the present time, according to Monsr. Skalkovsky, in addition to the two millions of tons of coal, or thereabouts, there are consumed in the manufactories of the country 2,216,885 cubic fathoms of wood and about a million and a half tons of charcoal. Wood is used for every purpose that it can be applied to, but, as its scarcity increases, coal will be looked upon as a necessity ; indeed, we cannot see how the iron trade can be developed in proportions at all commensurate with the legitimate requirements of the country unless coal be resorted to. This is made more plain by the remarks of the late Thomas John Taylor, in his *Archæology of the Coal Trade*, when alluding to the iron manufacture of Great Britain :—“ We cannot perhaps form a clearer conception of the value of our coal-fields,” he observes, “ than by estimating how much of another description of fuel might be required for this great national manufacture, which was so nearly extinguished a century ago. . . . It has been calculated that a ton of coal yearly is equal to the produce of at least four acres of growing wood, supposing the wood fit for cutting as fuel every sixteen years. Twelve millions of tons of coal yearly are therefore equal to the produce of 48,000,000 acres of wood. But the entire surface of Great Britain is about $56\frac{1}{2}$ millions of acres ; therefore nearly the entire surface of our island would be required to grow timber sufficient for the consumption of the iron manufacture alone.”

The great practical question which now presents itself is as to the probabilities of the future development of the coal and iron trades of

Russia. From personal observations, and from what can be learned from others who have visited the country, there is evidently an abundance of ironstone. It may safely be predicted that with the extension of railways and the development of mining, Russia will be, before the lapse of many years, in such a position as to be almost independent of foreign countries for minerals, although at the present time largely dependent on them, receiving as she does in addition to her imports of coal, which have been already mentioned, the following quantities of other minerals, viz.:—

						Tons.
Iron	...	...	...	...	...	224,045
Zinc	...	...	...	...	...	3,493
Lead	...	...	...	...	...	9,451
Copper	...	...	...	...	...	7,062
Salt	...	...	...	...	...	190,844
Steel	...	...	...	...	...	13,102

It seems rather uncertain whether Russia will ever be entirely independent of English coal, for it is probable that—at any rate in the Northern portion of her vast dominions—England may be able to command a market for coal of a quality which Russia may find profitable for certain purposes, notwithstanding its greater cost.

The actual extent of the coal-fields is yet a matter of uncertainty, but there is no doubt that those already adverted to are of such magnitude, that they will supply coal for an immense period; and if the coal measures should be found underneath the Permian formation at any reasonable depth, the supply would be, to all intents and purposes, inexhaustible.

In conclusion, it is surprising that the Russian Government, who, under the reign of the Emperor Alexander II., have pursued such liberal policy in giving every facility for the extension of the railway system, as evidenced by the great lengths of lines now in operation, have not extended the same to the development of the wonderful coal-fields of the country. Individual efforts have not been sufficient to develop coal-mining as it ought to have been, and it is probable that if the Government were to make proper explorations in places where coal would be most useful, and make railways thereto, the result would be most advantageous, and would hasten the arrival of that commercial prosperity which we know in our own country has its mainspring in coal.

The CHAIRMAN was sure the meeting would feel very much indebted to Mr. Simpson for his paper, as a source of information upon the coal

trade of Russia for future reference, and also as a general account of the geological formation of a country of which there is little or no record in this kingdom. He thought the paper was very valuable, and the Institute was particularly fortunate in having such a paper to form part of its transactions. He presumed that it was only the local demand which would ever cause these coal-fields to be largely developed. No doubt, the failure of the supply of wood fuel must compel the manufacturers in the district to enlarge their supply of coal; but it can scarcely be expected that such coals will ever become formidable competitors with those of this country. There appear to be only about two seams which contain less than from 15 to 20 per cent. of ash, and these would be of no value in competition with such high class coals as can be supplied from the South Wales and Newcastle coal-fields.

Mr. BEWICK stated that in the autumn of 1873, he had an opportunity of visiting the coal-field lastly referred to by Mr. Simpson, which was an extension of the very considerable basin of Upper Silesia, and which probably in outward appearances more closely resembles our English fields than the others mentioned by Mr. Simpson, inasmuch as the general outline of the country is similar, and the arrangements about the pits are more or less in the English style. The engines, whether for pumping or winding, are similar, and the workmen too are somewhat of the same type. Many are Poles, but the Prussians pass over the frontier and readily find employment. The strata are believed to form a basin, having towards the centre anticlinal and synclinal axes, similar to those Mr. Brown pointed out yesterday, as occurring in the South Wales coal-field. In fact, taking the Upper Silesian and Polish basin in its entirety, it may be said to consist of a series of small basins, all connected and forming one large field. The coal strata here rest upon the silurian rocks, the mountain limestone and old red sandstone being, so far as is known, absent. Overlying the coal formation are dolomitic rocks, in which are embedded large quantities of calamine and some lead ore. From the former, much zinc is manufactured in the neighbourhood, the production, in fact, being nearly double that of Great Britain. Much of the coal raised in Poland is used for smelting the calamine. The principal markets for the remainder are northwards towards Warsaw, and at that city. A portion is sent over the frontier into Austria, while in addition to the coal raised and used in Poland, Prussia (the district of Upper Silesia), in spite of a small duty, sends about 150,000 tons a year into Russia. The lowest seam in the series is about 21 feet thick in Poland, where it is not worked except at the outcrop, "quarry fashion," in the same way as ironstone is worked in

“patches” in South Wales ; not far off in Prussia what is supposed to be the same seam, is 26 feet thick, in one bed of pure coal, and is much wrought, the whole seam being worked away at once without loss. The upper seams are also good coal, some of them six feet and upwards in thickness. The coals in this basin are similar to those of the Northumberland and Durham field, but of a slightly higher specific gravity. A portion of the Polish field has been recently developed, with a view to an increased output. Large shafts have been sunk in pairs, powerful pumping and winding machinery erected, and every arrangement made for facilitating the operations. Some ordinary clay-band ironstone seams occur in the coal measures, which up to this time have been worked only to a very limited extent, but it is in contemplation to erect blast furnaces, and raise ironstone in larger quantities. There are good reasons for this ; wages are lower in Poland than in Prussia, and the arrangements of the Russian Government tend to the increased development of the iron and coal trades in their own country. The working classes are, as a rule, industrious and steady. They commence work at six in the morning, and, except an hour for dinner at mid-day, continue until six at night, all the year round. The only exceptions are the miners employed in sinking shafts and driving stone drifts, who work eight instead of twelve hours per day. His attention was called to the employment of women underground. They are mostly occupied in “putting,” and in such work are preferred to strong lads. One cannot but regret that women should be so employed, and this is more strongly impressed upon us when we see them in the dark recesses, and besmeared with the black dirt of the mine. In Prussia women are, by the laws of the country, not allowed to be employed underground, but many of them are so at bank, tipping coals, &c. In the neighbourhood of Königshütte and Kattowitz, towns which have sprung up like our own Middlesbrough, and similar places in England, there is a vast industry being carried on. In passing from Berlin by railway, on entering the coal-field of Upper Silesia, pits, blast furnaces, rolling mills, and almost every kind of coal and iron works—a veritable “black country”—suddenly appear before the traveller, and carry back his thoughts to the sights at home. Further on come the zinc factories, which have a less imposing appearance, but are nevertheless numerous, and add much to the importance of the district.

Mr. T. FORSTER BROWN asked Mr. Simpson whether he made any inquiries as to the uses to which English coal imported is applied ; because, as regards the future, it is an important question whether Russian coal is adapted for the purposes to which English coal is used in Russia ? Of course,

before any opinion as to the quantity of coal required can be arrived at, it will be necessary to get at the amount of wood used as well as coal. With respect to the Donetz coal-field, the Sea of Azoff is so shallow that it is necessary to carry the coal out in barges over long distances to the ship, which cannot approach the shores for many miles, and that will always operate as a drawback to any great development of over-sea trade. At the same time there can be no question about this, that the eastern part of the Donetz coal-field will be developed for the supply of steamers that navigate the Black Sea ; in fact, one of the lines of Russian steamers in that sea is exclusively supplied with coal from the eastern portion of this field.

Mr. J. M'MURTRIE said, with regard to that small Polish coal-field, it occurred to him that it might form a part of the belt of coal-measures which begins in South Wales and passes through a part of Europe. Prestwick, who has gone into the question somewhat fully, says :—"There is an anticlinal, beginning somewhere in Ireland, which passes through South Wales somewhere, the southern part of England, and Germany, to this district ; and if so, there may be some comparison made between the course of this coal-field and that of Central Russia, and those of Scotland and Berwickshire, which in both cases lie to the east of the true coal measures of England."

Mr. BEWICK would ask if there is any prospect of railway communication with those coal-fields in the Ural? Because, no matter how thick the seams may be, or how good the quality of coal, it may be said to be of no use, except for local purposes, without facilities for transit.

Mr. SIMPSON stated, in answer to Mr. Brown's question as to the use of English coal, that at Moscow, English gas coal costs about 60s. a ton, and the lignite which occurs 200 miles south of Moscow comes to about 25s. a ton, whilst the anthracite from the Donetz coal-field, 1,000 miles distant, cost about 38s. a ton. The English coal is generally used for making gas, and for other manufacturing purposes. To St. Petersburg the freight is not so great, and the price of English coal there is not out of the way ; but in other parts of the country the carriage would be a material consideration, and that would induce the people to put up with an inferior quality of coal of a less evaporative power than English coal. With regard to the Ural coal-field, he understood a line of railway is being laid out or made from Moscow or Nigni Novgorod to Perm, and in that case it will enable that field to be more advantageously opened out. It may be broadly stated that the cost of railway carriage in Russia is about half-a-penny per ton per mile. There is a difficulty in getting the Donetz

coal to port, but it will be of value for local purposes. The sugar factories are commencing to use it, and are having boilers fitted up specially for its consumption; and the railway companies are paying attention to it for locomotive purposes. But until recently the saving between the use of wood and coal was divided—half going to the railway companies and half to the stokers, as an inducement to the latter to burn coal. Mr. McMurtrie had touched upon a great question. No doubt, from their general appearance, it is evident that whether in Russia, on the Continent, or in this country, all those coal-fields are referable to a particular age.

Mr. BEWICK—With reference to what Mr. McMurtrie had mentioned, in addition to those fields there are those in Westphalia, Saxony, and Bohemia, in the same range, and all being developed. The whole of those are stone coals as distinguished from lignite. He had visited those fields, and there is a great similarity between them, but there is in each of them—except the Westphalian—an entire absence of the mountain limestone and the old red sandstone, as both the Saxon and the Bohemian rest upon the Silurian rocks. In Saxony they have a thick seam, which in places is worked 27 feet thick, at 2,000 feet depth, where the temperature is 104° F.; and in another place it is said to have been bored through 40 feet thick, and many pits are being sunk to it. In Bohemia, which is only just across the border, they have a good bed of coal 33 feet thick, but with some bands in it; in Saxony and Poland the best seams are entirely free from band.

The PRESIDENT said, he was sure it would be a pleasure to those present, to pass a vote of thanks to Mr. Simpson for such an important paper, which conveyed information which was perfectly inaccessible from any other source. Papers of this kind have their special value, and the same observations will apply to Mr. Bewick for the information which he has supplied.

Mr. DAGLISH then read a paper "On the Ironstone Beds of Lincolnshire," the joint production of Mr. Howse and himself.

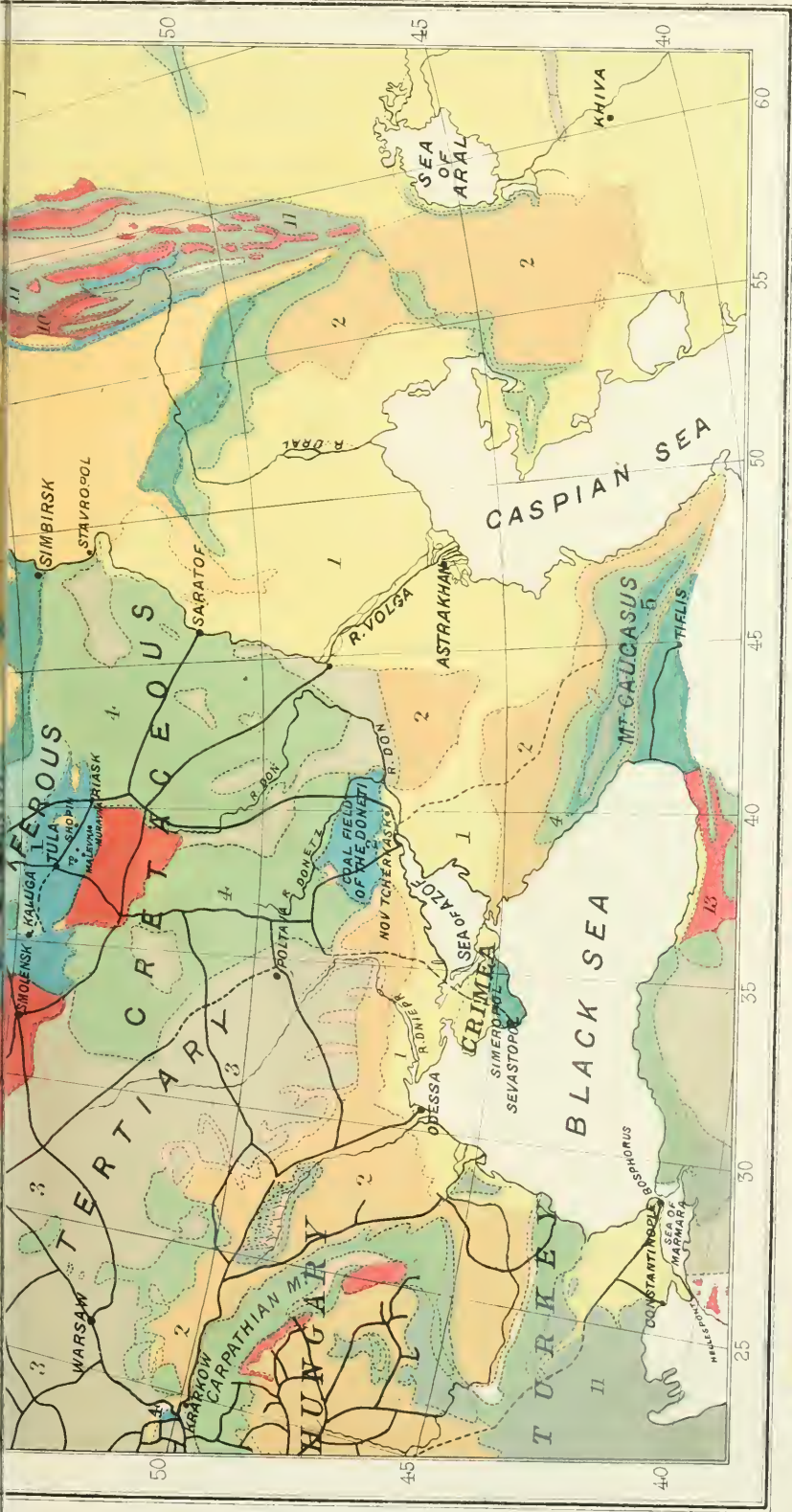
To illustrate Mr. J. B. Simpson's paper on "The Coal Fields of Russia."

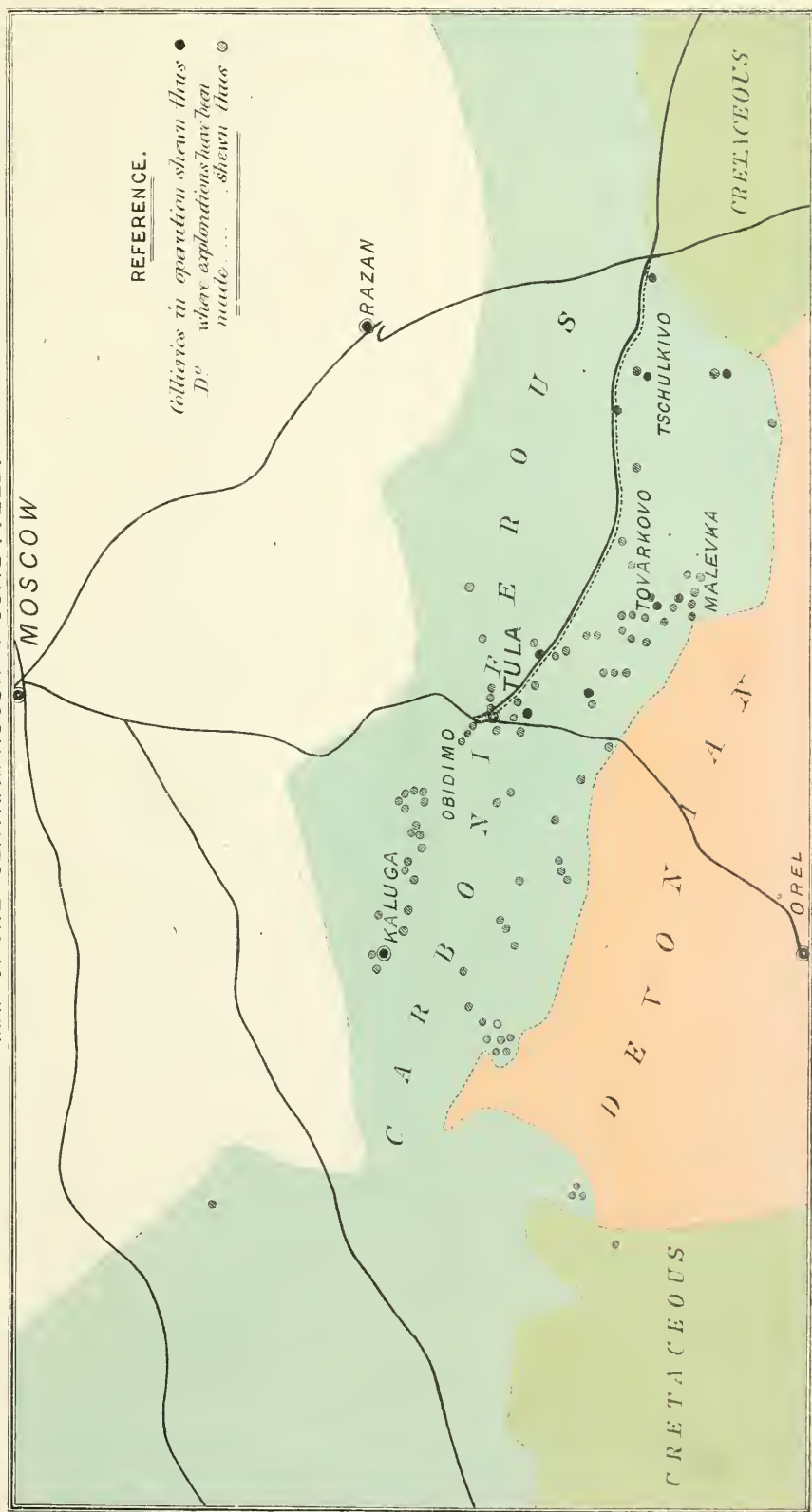
GEOLOGICAL MAP OF RUSSIA.

(From General Hedberg's)

1. Central Russian, or Moscow Coal Field.
2. Donetz Coal Field.
3. Ural Coal Field.
4. Coal Field of Poland.
5. Coal Field of the Caucasus.

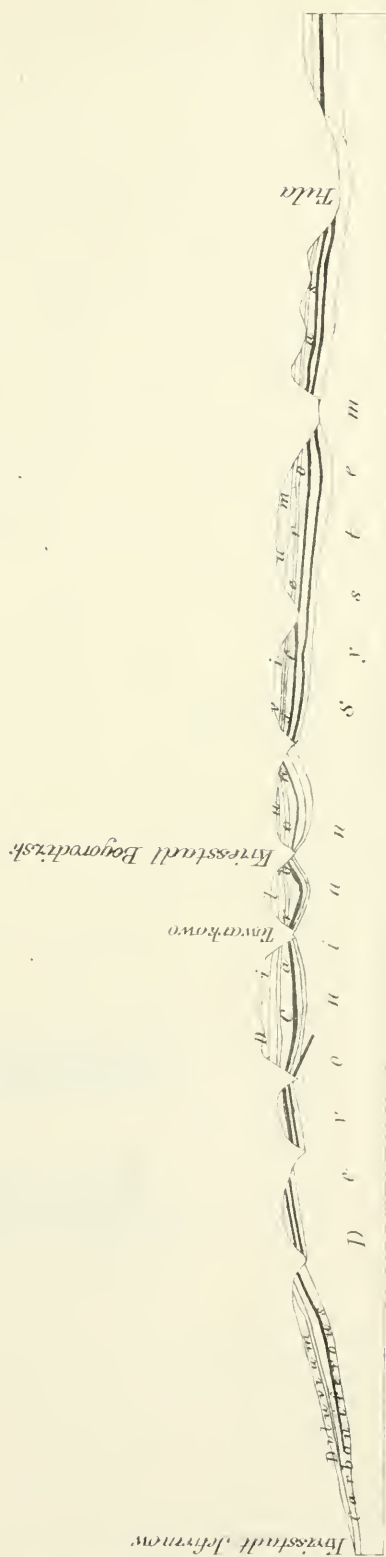




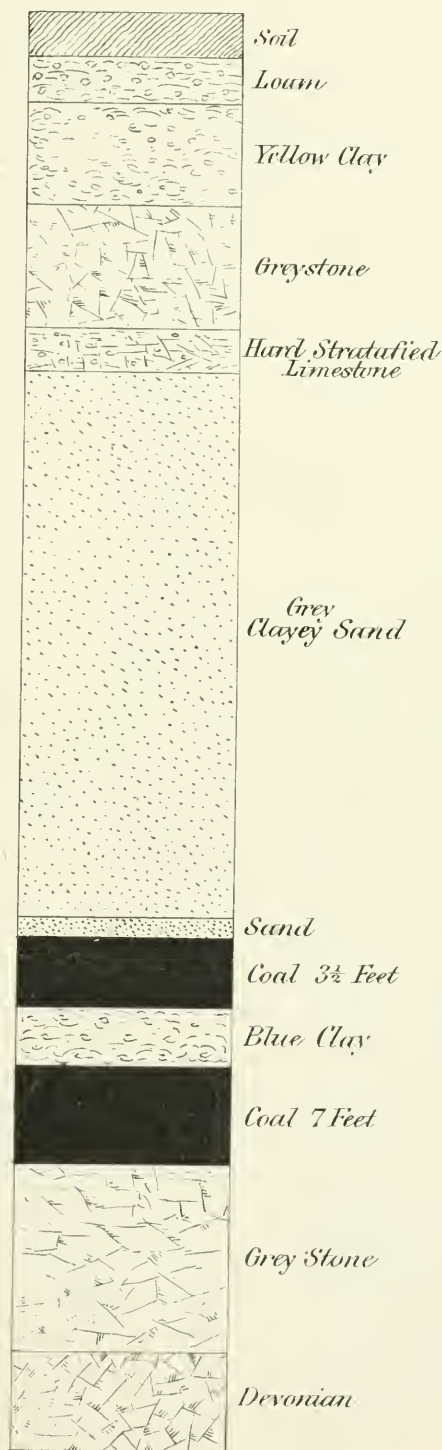


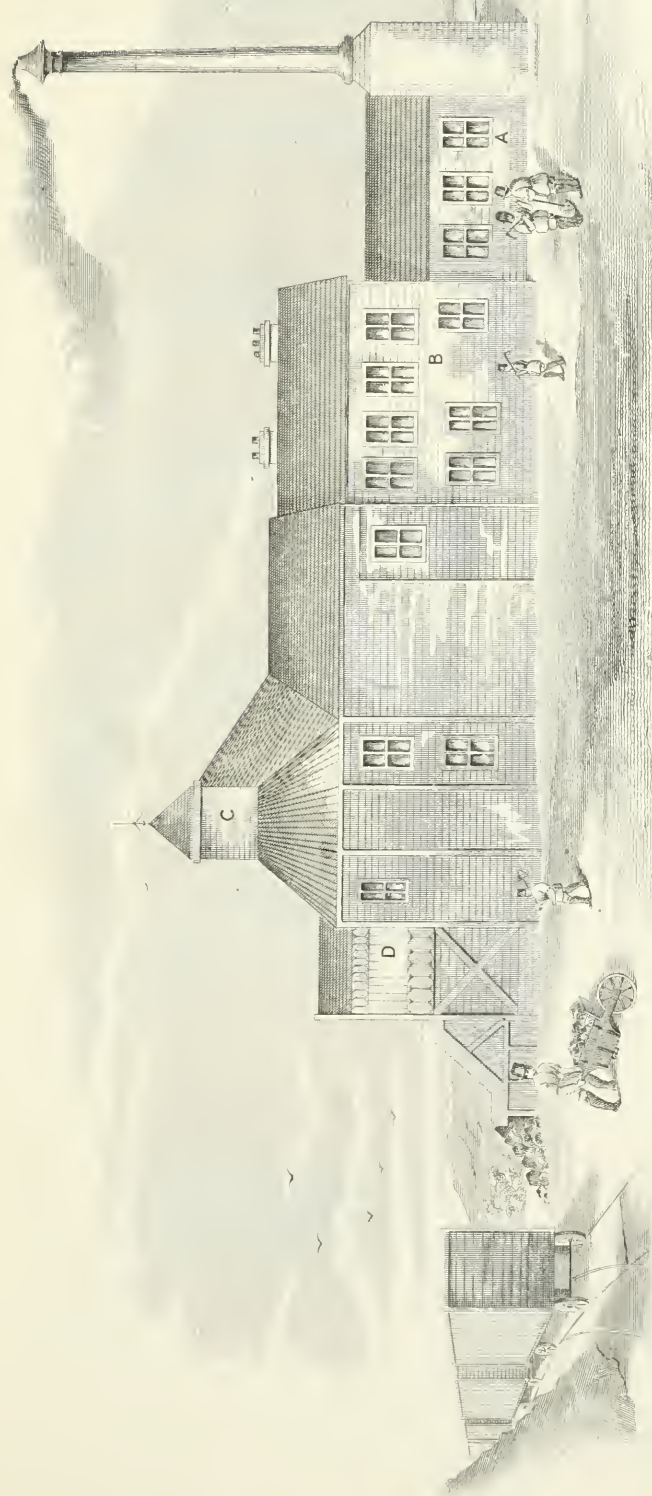
To illustrate Mr. J. B. Simpson's paper on "The Coal Fields of Russia"

SECTION ACROSS A PORTION OF THE CENTRAL RUSSIAN COAL FIELD.



SECTION OF STRATA, TULA DISTRICT.





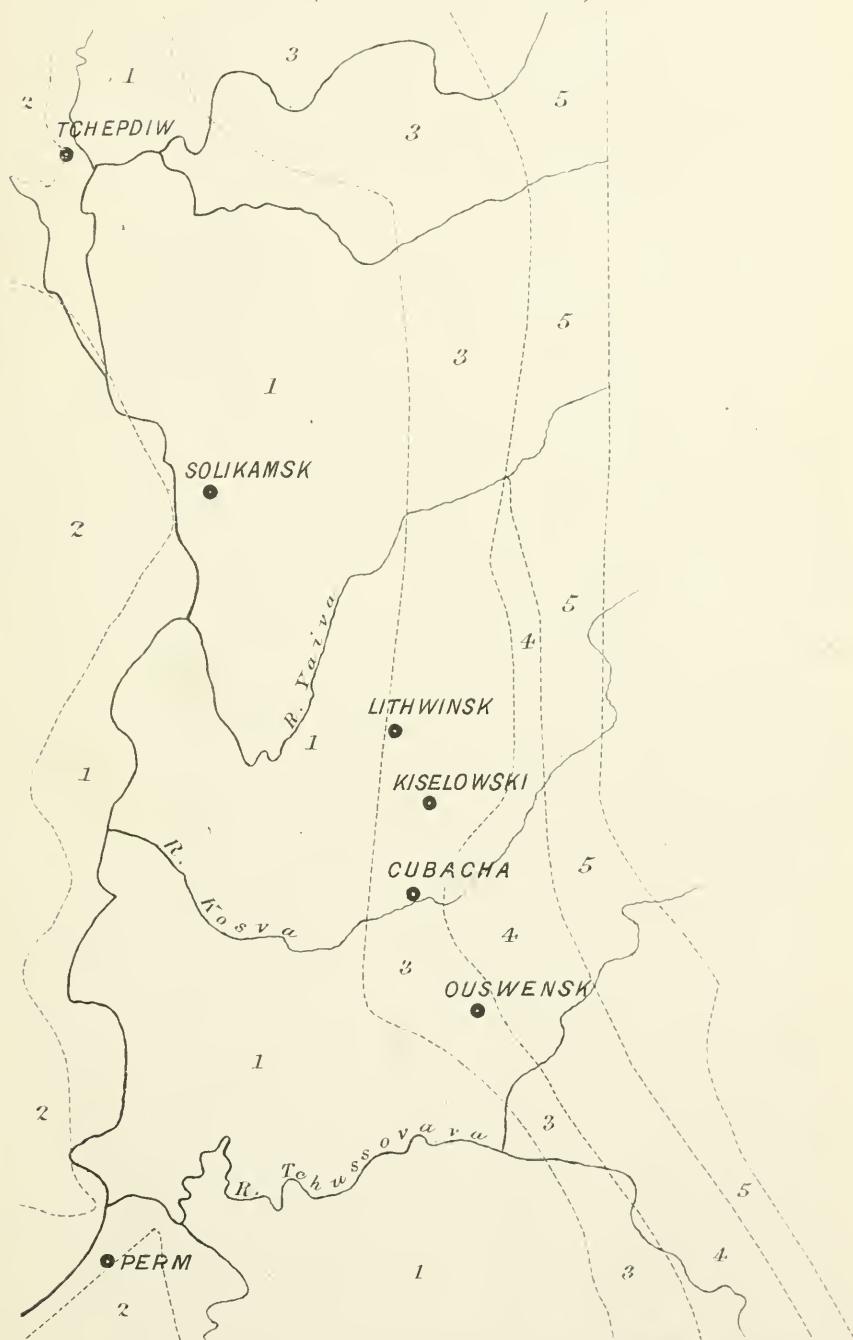
SKETCH OF THE EXTERIOR OF A RUSSIAN COLLIERY AT TCHULKOVO, GOVERNMENT OF RAZAN

A Boiler House. B Engine House. C Postern of Pullies. D Heapstead.

To illustrate M. J. B. Simpson's paper on "The Coal Fields of Russia."

MAP OF A PORTION OF THE URAL COAL FIELD.

(From Valerian de Meulen)



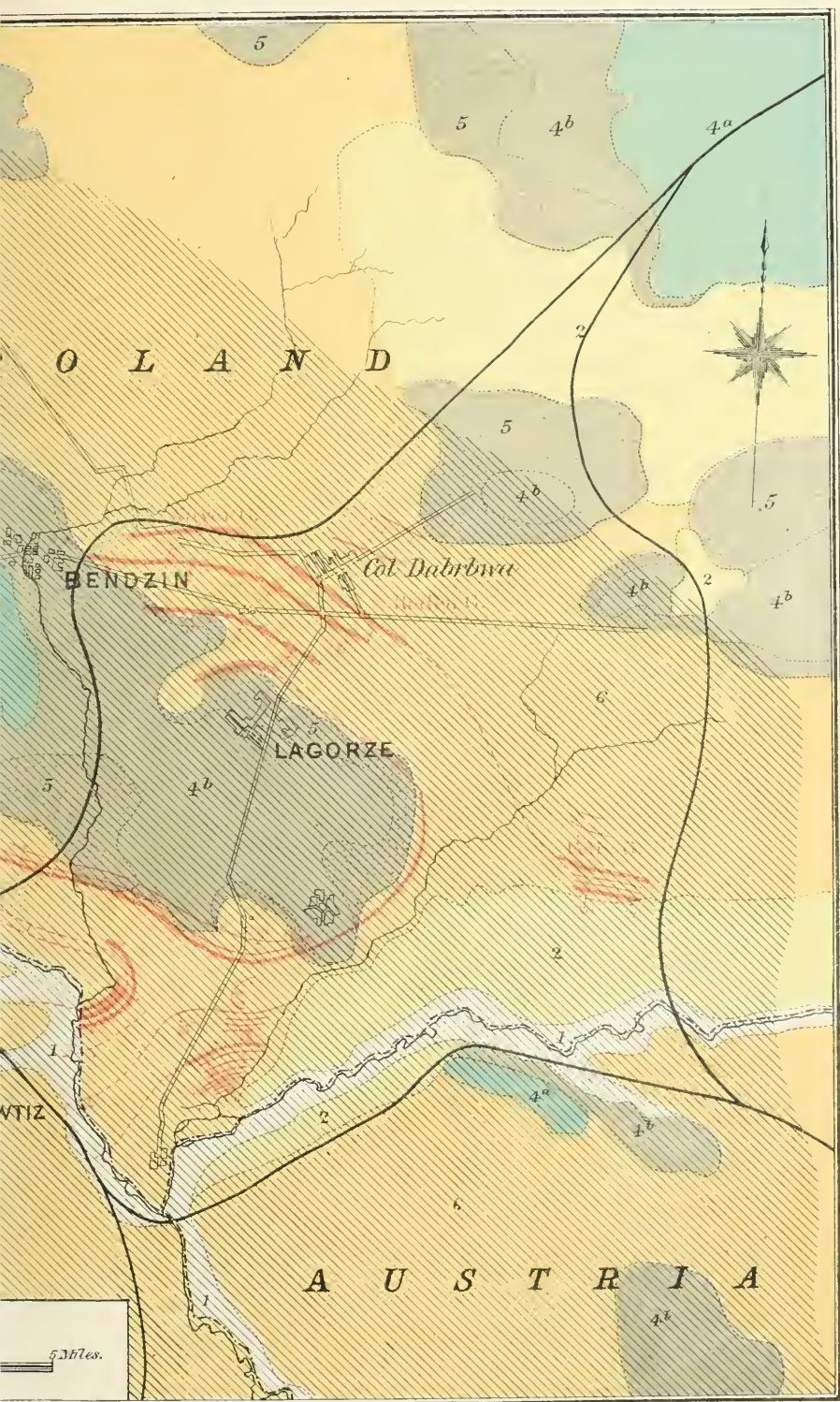
1. Triassic. 2. Permian. 3. Carboniferous.

4. Devonian. 5. Silurian.

COAL FIELD



POLAND.



SOME REMARKS ON THE BEDS OF IRONSTONE OCCURRING
IN LINCOLNSHIRE.

BY MR. J. DAGLISH AND MR. R. HOWSE.

As not much information has been published on the various beds of ironstone now being extensively worked in Lincolnshire, a few remarks, based upon observations made during one or two visits, may not be out of place at this meeting.

The ironstone beds, which are quarried or mined in this county, are situated in very different geological formations. They occur in the Lower and Middle Lias, in the Lower Oolite, and in the Lower Cretaceous or Neocomian rocks. The general map of North Lincolnshire (Plate VIII.) and the following section will illustrate this more clearly :—

Upper Cretaceous	{	White chalk.
	{	Hunstanton Red rock or Red chalk.
Neocomian	{	Red or brown sand.
or	{	Limestone.
Lower Cretaceous	{	Blue clay.
	{	Claxby ironstone. (1)
	{	Coarse green sand.
Upper Oolite	...	Kimmeridge clay.
Middle Oolite	...	Oxford Clay.
		Cornbrash.
Lower Oolite	{	Lincoln limestone.
	{	Lincoln ironstone (2)
	{	(Coprolite bed).
Upper Lias	...	Blue clay.
Middle Lias	{	Caythorpe ironstone. (3)
	{	Blue clay.
Lower Lias	{	Top ironstone. (4)
	{	Blue shale.
	{	Frodingham ironstone. (5)
	{	Beds of clay and limestone.
Trias	...	Keuper Marls and Sandstones.

Thus the lowest bed of ironstone (No. 5) in this series, which has been so extensively worked for many years near Frodingham station, on the Trent, Ancholme, and Grimsby Railway, is situated in the Lower Lias rocks. The thin bed (No. 4) seen in section near the same locality, is also in the Lower Lias.

Above this, another bed occurs (No. 3), and is at the top of the Middle Lias; this bed, which is not rich enough for smelting purposes in the north of the county, becomes very rich and is widely spread out and extensively quarried at Caythorpe near Grantham.

The next ironstone (No. 2) in the ascending series occurs in the Northampton sand, the lowest member of the Lower Oolite, and is the equivalent of the valuable ironstones worked in the neighbourhood of Northampton. At Lincoln, and in that neighbourhood, it is also very well developed, appearing in the escarpment of the hill on which part of the city is built; and on the opposite side of the valley where it is easily worked and of considerable thickness and good quality.

And lastly, another ironstone bed (No. 1) occurs in the escarpment of the chalk wolds in the neighbourhood of Claxby and Caistor, and is extensively mined near the former locality. This bed is situated in the Neocomian or Lower Cretaceous series of rocks.

LOWER LIAS IRONSTONE.

The Frodingham bed (No. 5), which appears to be placed about the middle of the Lower Lias, has a maximum thickness of 25 feet. It is, however, much denuded, and the top beds are, therefore, not on throughout the existing open workings; it is generally covered with a very variable thickness of loose sand, which shifts about with strong winds, and belongs to the superficial covering of the district. This bed is, and has been for ages, much exposed to the action of water, which rapidly passes through the sandy covering, and affects, as stated hereafter, the weight and quality of the ore. In its present form it is a calcareous hydrated oxide, with occasional traces of beautiful oolitic structure. It is composed of bands of poor and rich ore, the richest layers or bands containing nearly 40 per cent. of metallic iron, and the poorer hard shelly and calcareous bands as little as 12 per cent. Much of these poorer bands is thrown aside in the workings: practically the average proportion of metallic iron may be taken at 25 per cent. from the marketable stone.

This bed following the general dip of the district inclines gently to

the east ; it is not much disturbed by faults or foldings, and being only thinly covered with sand over a very large portion of flat country, is very favourably situated for open working or quarrying, the only mode yet adopted for obtaining the ore (see Plate IX.). The barren warrens and unprofitable lands under which it passes also serve to render this method of working not objectionable. The rapid development of this ironstone field is due in great part to these favourable conditions, which enable a large output to be obtained at a very low cost, large contracts having been made to supply ironstone at 3s. per ton delivered at the furnaces over a period of years. At the present date an area of nearly one square mile has been more or less opened out. Two pits of considerable depth have, however, been bored and partially sunk to this ironstone bed, near Appleby, at a distance of nearly three miles to the east of Frodingham ; a third pit has been sunk much nearer, and it is intended to mine the ironstone at these pits. The section and relative position of the strata at these shafts is shown on Plate IX.

The characteristic fossils consist of very large *Ammonites*, *Gryphæa incurva*, which latter occur in very great abundance in some of the beds, and several species of *Cardinia*. Numerous individuals of these, sometimes with species of *Lima*, *Pecten*, and other bivalve mollusca, compose almost entirely some of the bands, and render them, on account of the superabundance of lime and low proportion of iron, unserviceable for smelting purposes, and possibly to the presence of these is due the proportion of phosphorus contained in this ore.* In consequence of the large quantity of lime contained in this ironstone, no further addition is required as a flux to the furnaces : it is in fact found advantageous to mix with it a portion of silicious ore, such as that worked near the city of Lincoln, hereafter referred to.

In some of the beds the traces of oolitic structure are very distinct, but much decomposition has taken place between the harder bands, and the original structure of the rock has been destroyed and reduced to a brown powder. Many of the shells had been much rounded by the trituration action of water previous to their deposition, thus indicating the formation of this deposit in a comparatively shallow estuarine sea. Further south, as at Kirton Lindsey, where the ironstone bed has been proved at a depth of fifty yards, it is said to be too calcareous to be profitably worked for iron.

* A large tooth of *Ichthyosaurus communis*, much rounded and water-worn, and several large pieces of wood were obtained from this ironstone bed.

The first blast furnace was erected at Frodingham, in 1864, by Messrs. Dawes, and there are at present thirteen in blast and six others building, viz. :—

				Working.	Building.
Trent Iron Co. (Dawes and Co.)	...	...		3	4
Frodingham Iron Co.	...	...	...	4	
North Lincoln Iron Works (Adamson and Co.)				2	2
Lincolnshire Smelting Co.	...	...	...	2	
Redburn Iron Co.	...	...	...	2	
				—	—
				13	6

The furnaces recently erected by the two latter Companies are 75 ft. high, and 21 ft. in the bosh ; but those built and building by Messrs. Adamson are only 50 ft. high, and 19 ft. in the bosh ; both are stated to work well. The maximum yield of each furnace being 50 tons per 24 hours. During dry weather the quantity of ironstone required for the ton of pig-metal falls as low (under favourable circumstances) as 3 tons 15 cwt., rising to more than 4 tons in wet weather. In some of the furnaces coke only is used from Durham and from South Yorkshire ; in others coal from South Yorkshire is mixed with coke in the proportion of one-sixth of coal.

The authors are indebted to the kindness of Daniel Adamson, Esq., and G. Tosh, Esq., of the North Lincoln Iron Works, and to John Roseby, Esq., for the following analyses, in addition to much other information connected with the ironstone field.

ANALYSIS OF IRON ORE FROM THE MAIN BED OF IRONSTONE NEAR FRODINGHAM.

FIRST SAMPLE (RICH).				SECOND SAMPLE (POOR).			
Peroxide of iron	...	42·24	}	Ferric oxide	...	...	18·85
Protoxide of iron	...	4·16					
Oxide of manganese	...	1·37		Manganic oxide	...	...	3·50
Alumina	...	4·88		Alumina...	...	...	3·75
Lime	...	15·75		Lime	...	...	35·39
Magnesia	...	1·57		Magnesia	...	...	0·90
Phosphoric acid	...	0·46		Phosphoric acid	...	...	0·27
Sulphuric acid	...	0·02		Sulphur	...	...	0·05
Carbonic acid and water		22·76		Carbonic acid and water			34·82
Insoluble and silicious matter	...	5·28		Insoluble and silicious matter	...	...	2·80
		98·49					100·33
Metallic iron	...	32·93 per cent.		Metallic iron	...	13·20 per cent.	

This ironstone, therefore, may be classed as a calcareous ore.

ANALYSIS OF FORGE PIG IRON.

Iron	...	...	...	...	...	90·387
Manganese	...	...	...	...	...	2·374
Carbon as	{	Graphite	...	...	...	2·897
		Combined...	...	...	...	1·024
Silica	...	...	...	...	...	1·375
Sulphur	...	...	...	...	...	0·038
Phosphorus	...	...	...	...	...	1·232
Vanadium	...	...	...	...	...	0·146
Titanium	...	...	...	...	...	0·167
Cobalt and Nickel	...	...	...	...	...	0·360
						<hr/> 100·000

The output of this ironstone field (Plate X.) is expected to reach 500,000 tons during the present year (1874).

A bed of blue lias shale 80 feet or more in thickness, overlies and separates this bed from a thin bed of ironstone four to five feet in thickness (No. 4, Plate IX.). It is not considered of workable value; where exposed near Frodingham, and at Cleatham, near Kirton Lindsey, seen it is full of large *Pectens*, *Pholodomya*, etc., and other shells characteristic of the Lower Lias. The shale below is also characterized by a large variety of *Gryphæa incurva* and below the ironstone occur numbers of *Plicatula spinosa*, a well-known Lower Lias fossil.

Another thick shale with large cement-stone nodules intervenes between this pecten-bed ironstone and the next ironstone bed (No. 3). This shale has been proved to be about 160 feet in thickness, and it is much used as a valuable brick-clay along its whole line of out-crop to the south. The cement-stone nodules do not appear to be much utilized, and are thrown aside as useless by the brick-makers. So far as can be observed this bed is singularly devoid of fossils. The writers saw only portions of a large Ammonite, and they cannot decide whether this bed should be grouped with the Lower or Middle Lias, though on account of the absence of *Gryphæa* they incline to place it with the latter.

MIDDLE LIAS IRONSTONE.

Near Frodingham, this ironstone bed (No. 3) has been proved in the sinking of the pits, but is not considered rich enough for smelting purposes. It may be seen also in the neighbourhood of Kirton Lindsey, and in two or three places further south following the line of the escarpment of the Cliff Range of hills; but in the more southern part of Lincolnshire, a bed in the same relative position, and without doubt identical, becomes considerably thicker and richer in quality, and has an extensive spread

with only a thin alluvial covering. It has been largely quarried, both as a building stone and for iron ore lately, at Caythorpe, near Grantham. The section of a pit near Caythorpe station is as follows :—

								Ft.	In.
Soil and rubble	...	...	...	...	...	...	...	4	0
Inferior ironstone (screenings and waste)	...	...	...	...	...	...	...	2	0
Good ironstone	...	...	...	...	...	...	...	3	0
Limestone band (slightly silicious)	...	...	...	...	...	...	...	0	9
Good ironstone	...	...	...	...	...	...	...	10	0
Sandstone impregnated with iron	...	...	...	...	...	...	...	0	6

In this section, the covering of the top beds and the bottom beds were not seen. The beds undulate a little, and dip nearly due east under the escarpment of the Cliff Range.

The Brachiopods, *Rhynchonella tetraëdra* and *Terebratulula punctata*, well-known and characteristic fossils of the Middle Lias, were very abundant in this bed. Both these shells occur at Skinninggrave and in Cleveland.

A thick bed of blue lias clay or shale containing *Ammonites communis*, and other ammonites and fossils peculiar to the Upper Lias, separates this ironstone from the Northampton sand series, which latter is the lowest member of the Lower Oolite.

The main bed of ironstone, so extensively worked in Cleveland, may perhaps be correlated with that at Caythorpe, being in the Middle Lias. The following is an analysis of the Eston Mine ore :—

Peroxide of iron	...	...	...	...	...	3.55
Protoxide of iron	...	...	...	...	...	39.01
Alumina...	...	...	...	...	...	10.62
Lime	...	...	...	...	...	1.70
Magnesia	...	...	...	...	...	3.19
Phosphoric acid	...	...	...	...	...	2.08
Silica	...	...	...	...	...	10.90
Carbonic acid	...	...	...	...	...	25.26
Water	...	...	...	...	...	3.69
Metallic iron	...	...	...	...	...	32.83 per cent.

This iron may, therefore, be classed as a silicious carbonate of iron.

IRONSTONE OF THE LOWER OOLITE.

To point out the exact geological position of the ironstone bed worked at Lincoln, and to show that it is the equivalent of the ironstone quarried near Northampton, it will be best to describe the outcrop of the important bed of oolite limestone which forms the most striking feature of the rocks immediately overlying the Northampton sand series in Lincolnshire.

There is an old Roman road known as the Ermine Street, which runs nearly due north and south through Lincolnshire from near Winterringham, on the Humber, to Ancaster in the south. To the west of this road, a mile more or less, runs a line of escarpment called the Cliff Range, which seems to be broken by faults only to the north of Frodingham, at Lincoln, where the Witham passes through a valley of denudation, and at Ancaster ; from this latter point, the range becomes less distinct, and deviates to the west, and further south than the district to which these remarks are limited. This Cliff Range from the Humber nearly, and with only slight exceptions, indicates the line of outcrop of the lower portions of a thick series of beds of oolitic limestone, which, being so strongly developed in Lincolnshire only, is frequently called the Lincolnshire limestone. It thins out as it runs south, and is only feebly represented in Northamptonshire, and entirely disappears further south. Underneath this limestone, and following its line of outcrop, occurs a series of beds known as the Northamptonshire sand, in the central and lower portion of which the bed of ironstone worked at Lincoln is situated. This ironstone, so valuable in the neighbourhood of this city, appears to thin out in its northerly range, and to entirely change its character in the north of Lincolnshire ; but, as before stated, at Lincoln and to the south, it forms a valuable bed of iron ore.

The writers have been favoured by Mr. John Pattinson, Analytical Chemist, Newcastle-upon-Tyne, with the following analyses, of the "Lincoln" and "Northampton" ores :—

ANALYSIS MADE ON SAMPLES DRIED AT 212° FAHRENHEIT.

					Northampton- shire Ironstone.	Lincoln Ironstone.
					Per cent.	Per cent.
Peroxide of iron	...	...	...	...	51.00	47.71
Protoxide of manganese	...	...	...	...	0.30	0.32
Alumina	...	...	...	...	8.50	6.20
Lime	...	...	...	...	2.00	4.39
Magnesia	...	...	...	...	0.56	0.41
Silica	...	...	...	...	24.20	25.53
Sulphur	...	...	...	...	0.06	0.46
Phosphoric acid	...	...	...	...	1.32	1.50
Loss by calcination	...	...	...	...	12.10	13.40
					100.04	99.92
Metallic iron	...	...	...	...	35.70	33.40
Moisture in samples as received	...	...	...	...	4.90	7.50
Metallic iron in samples as received	...	...	...	...	33.95	31.45
Metallic iron in calcined stone	...	...	...	...	40.61	38.57

At Lincoln, this bed of ironstone is quarried under favourable circumstances on both sides of the Witham, at Greetwell, and at Washingbrough and four miles south, at Waddington. It is here about 8 feet thick, and is separated at these localities by a thin bed called the coprolite bed from the Upper Lias shale. It may be termed a silicious oxide containing nearly 40 per cent. of metallic iron, but in some of the trial pits north of Waddington, and in some sinkings to the dip where it has more covering, it is stated to take the form of a carbonate. The authors hope to lay before the members of the Institute specimens of this bed of ironstone showing the passage from the carbonate into the oxide. At Waddington it is separated from the oolite limestone by a bed of sand containing layers of sandstone with annelide markings on their surface. Further north than Lincoln, along and under the Cliff Range, this ironstone appears to deteriorate in quality, and to be represented by ferruginous sand or sandstone, and blue shale containing a few fossils, but not sufficiently well preserved to allow of strict identification. These sandy beds appear to belong to the Lower Estuarine series of the Government Geological Survey.

The following analysis and the section given in Plate XI. were supplied by the kindness of Mr. T. Clench. The latter will give a very correct idea of the constituent parts of this bed of ironstone and the quality of the ore :—

Peroxide of iron	...	...	...	...	...	58·06
Protoxide	...	...	...	...	...	.....
Protoxide of manganese	...	...	...	...	...	·02
Alumina	...	...	...	...	...	6·10
Lime	...	...	...	...	...	2·94
Magnesia	...	...	...	...	...	·89
Carbonic acid	...	...	...	...	...	1·87
Silica	...	...	...	...	...	13·17
Sulphur...	...	...	...	...	...	Trace
Phosphoric acid	...	...	...	...	...	·80
Water combined	...	...	...	...	...	11·86
Moisture...	...	...	...	...	...	4·29
						<hr/> 100·00

LOWER CRETACEOUS OR NEOCOMIAN IRONSTONE.

At Claxby, near Caistor, about fifteen miles east from Frodingham, a bed of ironstone is extensively worked. This ironstone is also a calcareous hydrated peroxide, containing 25 per cent. of metallic iron. On referring to the section given previously, on page 23, it will be seen that this bed is situated in the Middle Neocomian series; the part workable to profit is about 7 feet thick, and abounds with the shells of *Pecten cinctus*; fifty

thousand tons of the ore were worked last year entirely by mining, and exported from the Holton-le-Moor station, of the Manchester, Sheffield, and Lincolnshire Railway, to the blast furnaces of the West Yorkshire Iron Company, near West Ardsley, in Yorkshire, and the writers are indebted to the courtesy of the managing proprietor, Mr. W. Firth, for kindly permitting an examination of the mine, and for affording much valuable information.

The section of the cliff near the entrance to the mines presents the following series :—

					Feet.
Lower Cretaceous	Hunstanton red Rock or Red Chalk.				
	Brownish sand	...	...	...	20
	Hard limestone	...	...	...	10
Neocomian	Blue clay	...	...	...	50
	Ironstone bed	..	...	...	10
	Coarse sand	...	...	...	12
Upper Oolite	...	Kimmeridge clay.	Dark bituminous laminated shale.		

In a paper on these rocks, contributed by Mr. Judd to the Geological Society (Vol. XXVI., page 329), he mentions “the existence of fragments of iron slag, calcined ore, and charcoal, associated with Roman pottery, indicating that these ironstones were known and worked at a very early period.” He also alludes to “the similarity in every respect of this ore with that which has been worked for so many years at Steinlahde and Osterholz, near Salzgitter, and at some other points in North Germany in the same series of rocks.”

EXPLANATION OF PLATES.

Plate VIII.—General Geological Map of North Lincolnshire, showing outcrop of ironstone beds.

Plate IX.—Section shewing the contour of country East of Frodingham Ironstone Fields.

Plate X.—Plan of the Frodingham Ironstone Fields.

Plate XI.—Section of the Lincoln or Northampton Ironstone, in the Coleby Shaft, South of Lincoln.

Mr. FORSTER BROWN stated that he was exceedingly interested in getting information as to the difference of the percentage of iron in the stone worked from the shafts as compared with that taken from the outcrop. The secret of the success of the present working was that the stone was got at easily and cheaply, and he would like to know what is the precise nature

of the underground stone to make its working more profitable when it is so much more expensive to get ; is it more compact in itself and more easily smelted, as is the case in the Cleveland district.

Mr. GREENWELL said, in Wiltshire the ironstone is, in the coral rag changed in colour to a reddish brown—a sort of hydrated peroxide containing 34 per cent. of iron. The same beds in the district where covered by Kimmeridge clay, were a compact green ore containing 31 per cent. of iron. In that condition it required to be calcined before being put into the furnace, but where it is found in the oxidized state it is put into the furnace raw. He made these statements in order to ascertain whether the same relative condition of things was found in Lincolnshire that they found in Wiltshire. He should like to ask a question as to the exact position of the Lincolnshire ore. He observed in the section that it is above the Kimmeridge clay. At Westbury it is lying immediately under the Kimmeridge clay.

Mr. BEWICK thought it would be of interest to know the relative proportions of ironstone worked in this district from underground and surface working, and whether the former has been sufficiently developed to determine what is the nature of the stone. The oolitic ironstone at Towcester, which is further south than the district Mr. Daglish delineates on his plan, has been opened out extensively by quarries. Where not denuded, it is from 6 feet to 8 feet thick, and, being close to the surface, is worked cheaply, and if mixed properly, is understood to work with great advantage in the Staffordshire furnaces ; but while the oolitic is thus worked, the lias can only be wrought by underground operations. Messrs. Lloyd are opening out extensive fields of the former kind and sending it into Staffordshire, where large quantities are likely to be required. It is of the oxidized character, and sometimes in the centre of a piece a heart of green stone is found, something similar to that of Cleveland.

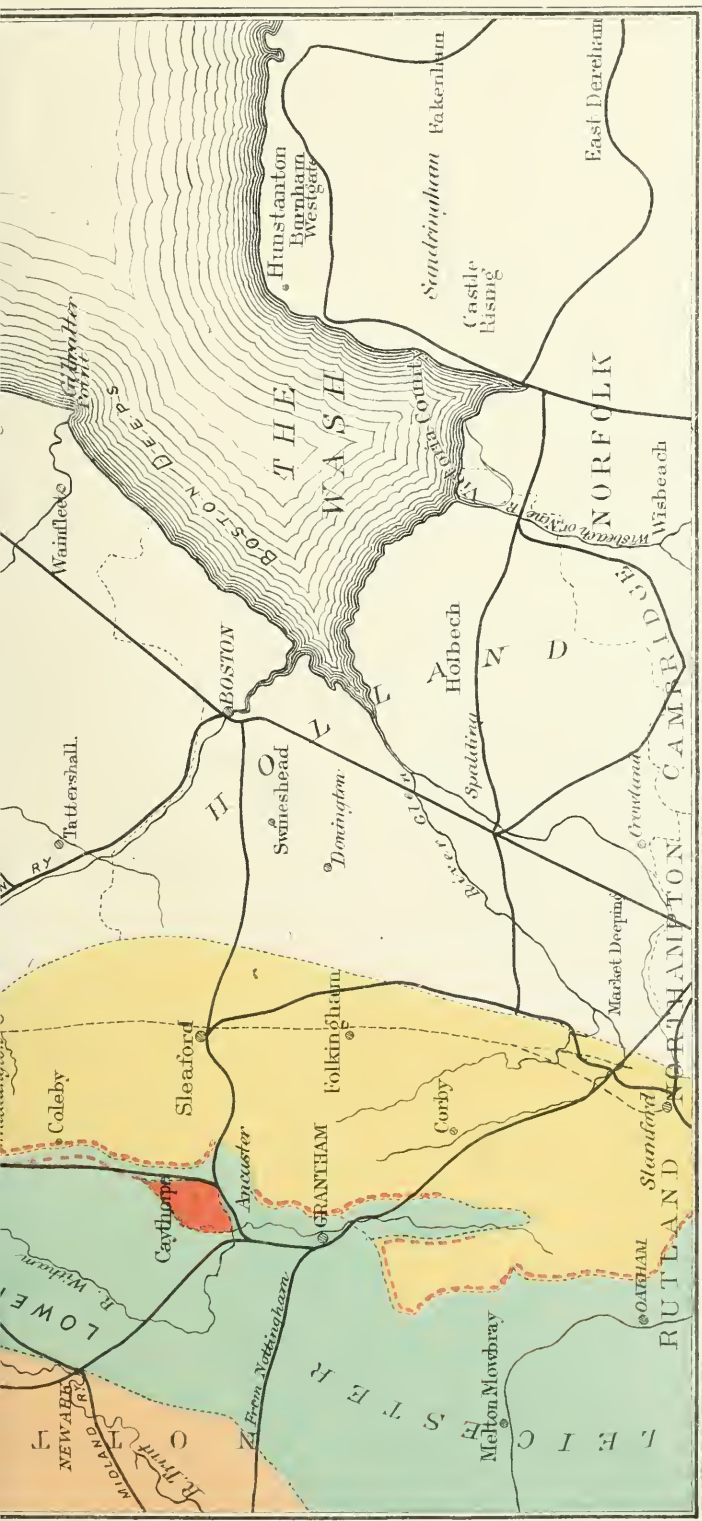
Mr. W. COCHRANE thought it necessary to call particular attention to a point which Mr. Daglish had brought out, and that was the large percentage of lime in this stone. It is not so much a question of the stone being of inferior quality at the outcrop due to mechanical condition or the infiltration of water, but to the fact that the limestone is present to such an extent as to render the ore too calcareous for profitable working. That is the difficulty with the Lincolnshire ironstones and the difference between them and the Northamptonshire ironstones. In Northamptonshire, near Thrapstone, they work the ironstone quite at the outcrop ; sometimes they have simply to turn up the soil and find hard solid rock from 8 feet to 10 feet thick, the iron yielded being from 30 to 40 per cent. He would ask

To illustrate Messrs Dalish & Hawes' paper on "The North Lincolnshire Ironstone Field."

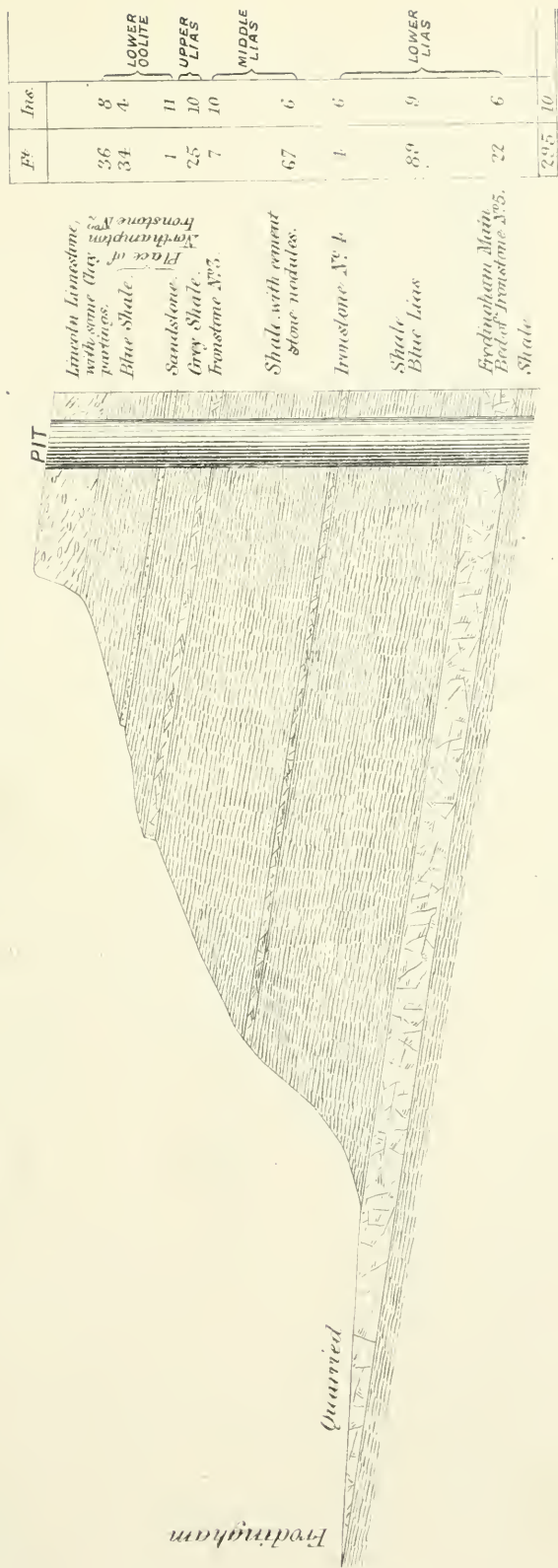
GENERAL GEOLOGICAL MAP OF NORTH LINCOLNSHIRE.

Scale of Miles.
0 1 2 3 4 5 6

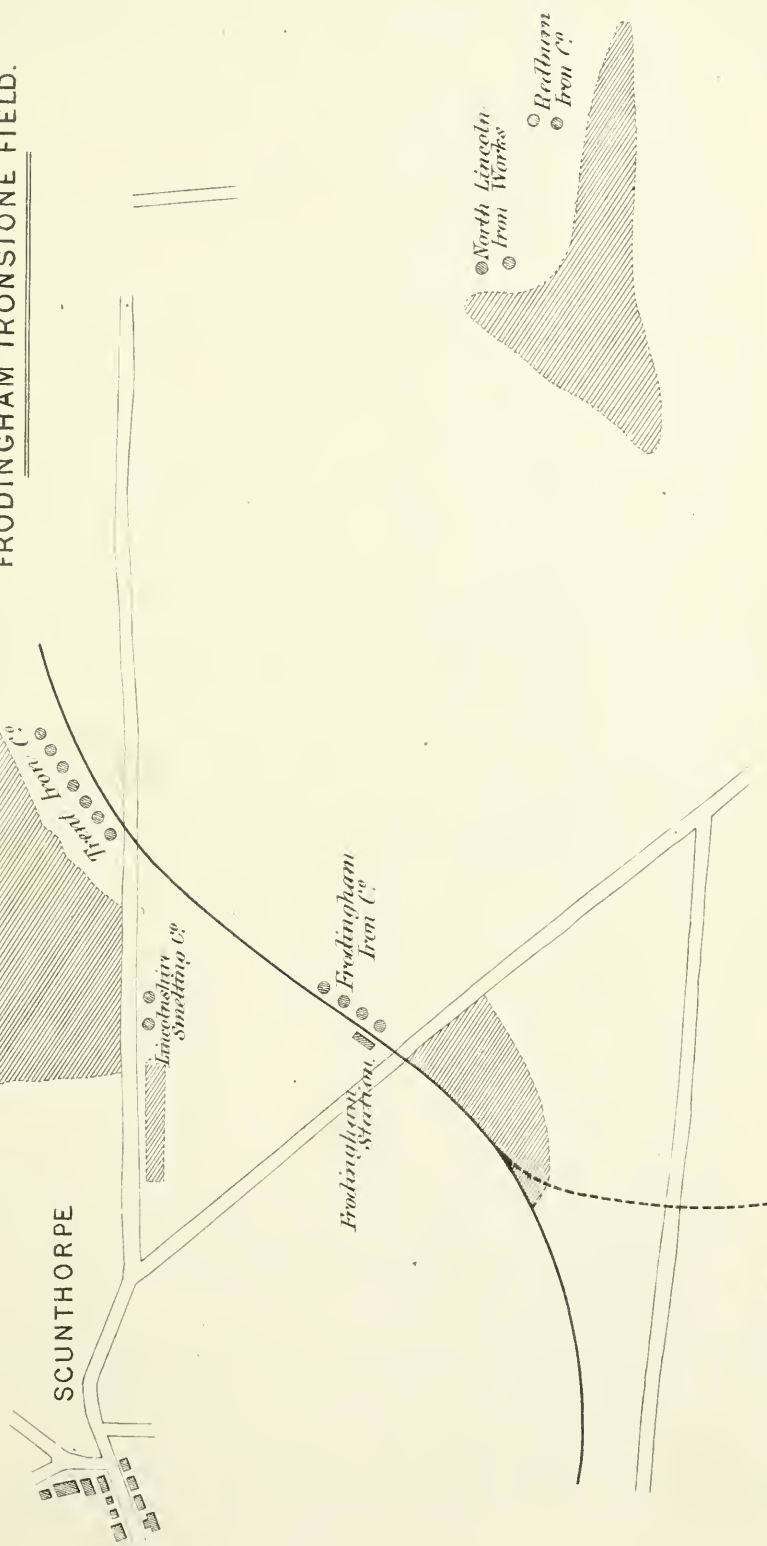




SKETCH SHEWING CONTOUR & SECTION OF COUNTRY EAST OF FRODINGHAM.



FRODINGHAM IRONSTONE FIELD.



To illustrate Messrs Dargish & Howses paper on "The North Lincolnshire Ironstone Field."

COLEBY SHAFT, SUNK 15 YARDS THROUGH THE LINCOLNSHIRE LIMESTONE, TO THE BLUE IRONSTONE.

		Lincoln Oolite		Feet	Lower Oolite
N ^o 1	Peroxide	N ^o 1		8 inches	
" 2	Clay mixed with Ironstone	" 2		4 "	Northampton Sands.
" 3	Hard Blue Ironstone	" 3		9 "	
" 4	Clay Parting	" 4		3½ "	
" 5	Hard Blue Ironstone	" 5		16 "	
" 6	Peroxide Girdles	" 6		1 "	
" 7	Soft Blue Ironstone	" 7		9 "	
" 8	Nodule Bed, Blue	" 8		5 "	
" 9	Parting	" 9		½ "	
" 10	Ironstone Nodules Blue	" 10		6 "	
" 11	Blue Silicious Ironstone	" 11		13 "	
" 12	Blue Nodule Bed	" 12		6 "	10 Feet Clay
" 13	Clay with Nodules	" 13		36 "	
" 14	Coprolite Bed	" 14		3 "	
Total Thickness 10 ft				10 Feet Clay	Upper Lias
" 15	Blue Lias Clay	" 15			

whether Mr. Daglish had known any instance of a bed of ironstone passing gradually into limestone. The percentage of iron in some of the stones Mr. Daglish describes being only 13, is so small, that it would be perhaps more correct to call the stone not an ironstone but a ferruginous limestone, and he would be obliged if Mr. Daglish could state the quantity of coke and coal necessary to produce a ton of iron.

Mr. DAGLISH—With regard to the observations of Mr. Brown, who asked a question as to the condition of the ore at the outcrop and of the ore that would be taken out by mining, he would state that at present it is merely a matter of opinion, and that would answer the question of Mr. Bewick also, because none of it is mined at present, all being worked at the outcrop. The top bed now being quarried is a disintegrated sand, and contains 40 per cent. of iron; he was told, however, by a blast-furnace manager that they could not get any iron out of it, and that that particular part of the bed, nearly two feet in thickness, was of little or no value in the furnace. Perhaps Mr. Cochrane did not quite understand the observation which he made about the different parts of the seam; it is in alternate layers or bands, which, in fact, are cast out in the working, and not put into the furnaces at all. The difficulty mentioned as to the superabundance of lime is well understood, but they mix with the Lincoln and other ores, which are silicious. The quantity of ore expected to be worked this year at Frodingham is 500,000 tons, and at Claxby 50,000 tons. Mr. Cochrane asked whether those ores passed into a pure limestone. Now he was not aware of any case in which it did so in the district now referred to; on the contrary, the line of separation between the rich and poor ironstone is distinctly marked. In Teesdale, however, he had met with instances of the limestone and ironstone charging so that the eye cannot tell where it contains 50 per cent. of iron and where it does not contain any at all.

The PRESIDENT—Would you kindly say what proportion is rejected, whether from this sand cause or any other, because the mere picking makes some additional cost in utilizing the ore.

Mr. DAGLISH—The part they throw back in the quarries is not very great, but there would be some difficulty in determining the exact proportion.

The PRESIDENT moved that a vote of thanks be awarded to Mr. Daglish and Mr. Howse for their paper, which was cordially responded to.

Mr. WALKER then read a paper on "Detaching Hooks."

WALKER'S DETACHING HOOK.

BY W. WALKER.

Patent, No. 1,571.—1871.

On referring to Plate XII., it will be readily observed that the principle upon which this hook is constructed is of such a simple character as to render it especially applicable to the ordinary work of sinking pits, as well as to the process of raising any load, whether loose, like the kibble at the end of the rope, or secured in its travelling position, as cages are with skeets in ordinary working pits.

The chief feature of this hook is, that the load to which it is attached is made great use of in working, both when it is running in the pit, and when it is required to free the rope from its load, and yet it is so formed that it will work equally well without any load at all, and is thus possessed of a two-fold source of safety.

Fig. 1 is a front view of the hook.

Fig. 2 is an edge view of the hook.

Fig. 3 is a front view of the whole apparatus, with the supporting ring and clamp in section, showing the hook before the lifting rope is liberated.

Fig. 4 is the same, showing the hook just after the liberation of the lifting rope.

The same letters refer to the same parts in all the figures.

The lifting rope is attached to the shackle A, and the load to the connecting link B.

The supporting ring C (through which the rope is constantly working) is fixed in a baulk of timber, or iron girder, as near to the pulley as possible, and must be thoroughly secure.

The hook consists of a pair of jaws, D D, working on a centre pin, E, in such a manner that the weight of the load has a tendency to open the upper limbs, which clip the strong centre pin of the shackle A.

The upper limbs are formed externally with jaw hooks, F F. The jaws are kept together, and made to retain the shackle pin by means of the clamp H, which is held in position by the pins I I.

In case of overwinding, the jaw hooks (held together by the clamp) pass freely into the ring C, but the projections K K of the clamp coming in contact with the bottom flange of the said ring hold the clamp stationary, while the jaws are being pulled through, the result being that the pins I I are sheared off, and the jaw hooks released from the restraint of the clamp. The internal diameter of the ring being the same as the width across the jaw hooks F F, the rope remains secure until the jaw hooks reach the top of the ring, when, by the action of the weight of the load, they are forced open, and so hook on to the top of the supporting ring C, as shown in Fig. 4, the released rope passing harmlessly over the pulley.

The recess O in the ring C is intended to meet an imaginary case that experiment shows to be almost impossible, namely, that if the engine is reversed after the pins I I are cut, and before the hooks reach the top of the ring, the jaws will then hook into the recess, and the load remain suspended in perfect safety.

It will be observed that the upper edge of the ring C is curved to match the sweep of the jaw hooks when opening. By this arrangement all shocks are avoided.

Fig. 5 shows the apparatus applied to a pit in course of being sunk ; and Fig. 6 the case of a regularly working pit, with the cage suspended by the detached hook, in consequence of overwinding.

The internal diameter of ring C for carrying three tons is $4\frac{3}{4}$ inches ; for carrying four tons, $5\frac{1}{2}$ inches ; for carrying five tons, $6\frac{1}{2}$ inches ; for carrying six tons, $7\frac{1}{4}$ inches ; and for carrying eight tons, $8\frac{3}{4}$ inches. Whilst the length, including the shackle A and bottom link B, for a three-ton hook is 18 inches ; for a four-ton hook 1 foot 9 inches ; for a five-ton hook, 2 feet ; for a six-ton hook, 2 feet 2 inches ; and for an eight-ton hook, 2 feet 6 inches ; and the weight of the whole apparatus for carrying a load of six tons only amounts to 84 lbs.

This hook is applied to the ropes of deep sinkings, extensive working pits, and high blast furnace lifts in the north, and has also been thoroughly tested in this immediate locality, at one of the Llynvi Tondy and Ogmore Coal and Iron Company's pits, when their Mining Engineer (Mr. Birbeck), who was present, reported "that it placed the overwinding of any load beyond all possibility, and that it was also so simple as to recommend itself to every practical man, and its adoption would be readily embraced by every one interested in mining." Mr. E. Robson, of Middlesbrough, the

To illustrate Mr. W. Walker's paper on "Detaching Hooks."

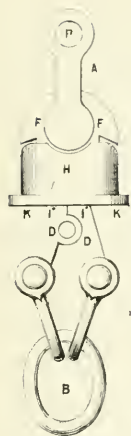


FIG. 1.



FIG. 2.

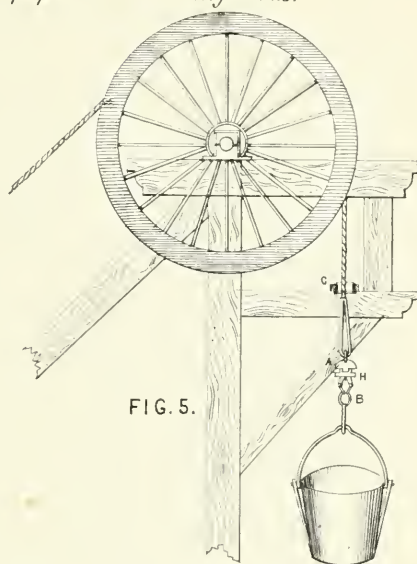


FIG. 5.

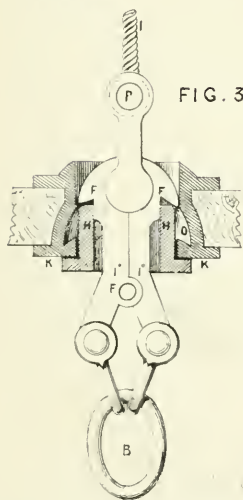


FIG. 3.

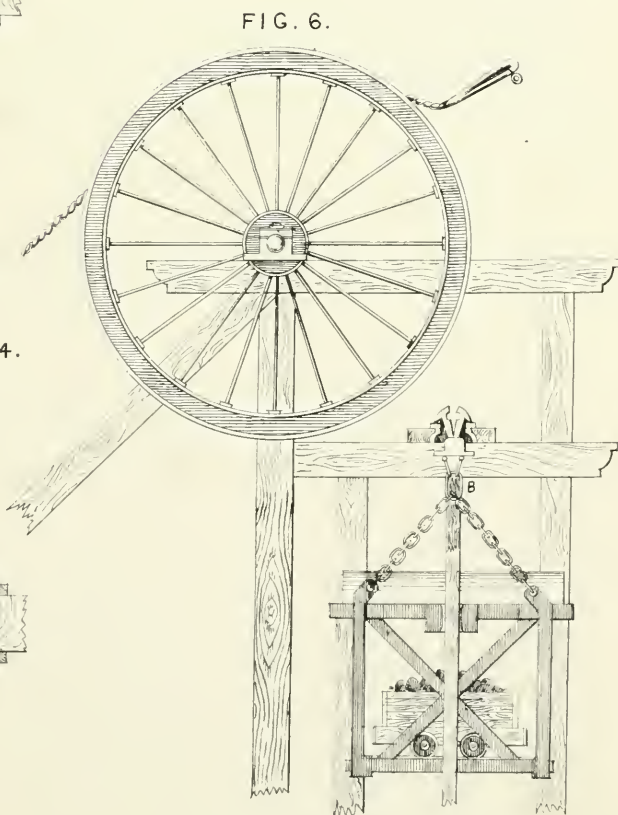


FIG. 6.

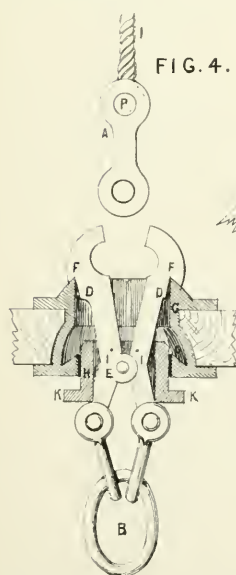


FIG. 4.

managing partner of several collieries and mines, where there are fifteen of these hooks at work, also speaks highly of its value and success.

Though all hitherto done to prevent the loss of life and destruction to property, resulting from accidents by overwinding, has been adopted only at those pits which have become so complete in their development as to be classified as "ordinary working pits," yet, any one practically acquainted with sinking, will readily admit the risk of accidents during this process is very much greater than in the everyday working of a pit yielding coal.

In the absence of any appliance to the ropes of an ordinary working pit, in case of overwinding, the rope will either give way at the socket and the cage fall back on to the keps, or the cage will mount and go over the pulley. While in the case of a sinking pit, where the men are working in the pit bottom, immediately under the load, which has no keps to fall on or skeets to secure its position, in an accident of this nature, the kibble would either fall back into the pit bottom, or, if taken over the pulley, the stones might fall out of the kibble within the pit mouth, and almost certainly cause loss of life.

Serious and often fatal accidents from overwinding are so frequently occurring at pits in all stages of progress and work, that it is hoped the bringing before this meeting of an invention which has already been introduced successfully for their prevention in the mining districts of the North of England may not be considered undeserving the attention of such an important scientific assemblage as the present.

On the motion of the President the thanks of the meeting were awarded to Mr. Walker for his paper.

Mr. WRIGHT, in the absence of Mr. Martin, read that gentleman's paper on "The Publicity or Secrecy of Examinations."

THE PUBLICITY OR SECRECY OF EXAMINATIONS.

BY R. F. MARTIN.

Read at the Joint Meeting at Cardiff, July, 1874.

THE writer would wish to draw the attention of the Institute to a question which appears to him to be of great importance, especially to the younger members.

It is now more than a year ago since he learned for the first time, with some astonishment, that it was not possible to obtain a copy of the questions which had been set at the examinations for certificates, under the Mines Regulation Act. Such a proceeding appeared to be arbitrary and altogether without precedent. Knowing how utterly impossible it is to control a large body of candidates in this respect (so large a body that even if they were effectually prevented from making any notes, they would usually have to remember scarcely one question each, in order to produce afterwards the whole paper), he could not believe that it was seriously intended to carry this out, but thought that the hands of the examiners must for the time be tied by some regulation which they could not avoid.

It now appears that this is the case, for all the Boards of Examination have received the following circular from the Home Secretary, through H.M. Inspectors of the respective districts:—

Whitehall, April 15, 1874.

SIR,—The attention of Mr. Secretary Cross having been called to the fact that questions set in examinations under the Mines Act, 1872, have frequently been made public, I am directed by him to request, that at the next meeting of the Board of Examinations for your district, you will call the attention of the Board to the impolicy of allowing such papers to be published, and suggest that, as in the case of the Civil Service examinations, a note should be appended to all examination papers, that they are to be considered as confidential, and are not to be copied or taken away; thus making the publication of the paper a breach of confidence.

I am, Sir, your obedient servant,

HENRY SELWYN IBBETSON.

It is difficult to imagine the reason for adopting such a course, unless it be that which was lately stated in public by the members of the Board at Derby. It appeared that this Board desired to avoid, as far as possible, the passing of candidates who have been specially "crammed" for examination, and that they considered that this end would be best attained by maintaining the utmost secrecy in the examination itself. The writer will presently attempt to demonstrate the fallacy of this opinion.

He would here suggest that the proper bodies to discuss this question, and, if necessary, to take it up, are our Mining Institutes; for this rule would appear to strike at the very root of the objects they have at heart. They are, above all things, educating bodies. Their chief aim has always been to disseminate technical education amongst their members; and one most effectual means to this end is the publication of comprehensive examination papers upon engineering subjects.

It is, moreover, hardly fair to the members who wish to pass these examinations that no better guide should be given them than the fact that they will be examined in such and such subjects. It is a course pursued, so far as the author is aware, in the case of no examination of any eminence except that for the Civil Service. Even in this case it will be remembered that, a few years ago, some splendid papers on general engineering were published by the examiners for India.

It is scarcely necessary to point out, that the case of the Civil Service is by no means parallel to the one we are now considering. A person who wishes to enter the service of the Government will conform to any rules that Government may choose to make as a condition of such service; but those, who do not seek employment at their hands, may fairly object to the imposition of rules hitherto applied to the case of their candidates alone.

The Memorandum which is to be signed by all candidates (in one district, at any rate), would appear to be tantamount to telling them that "They shall not have a chance of succeeding in their business; they shall not even be allowed to manage a mine, however competent they may be, unless they choose to conform to a certain arbitrary regulation, for which no good reason has ever been given, not prescribed by Parliament, but proceeding from the Home Office."

The unfairness will become more apparent still, when it is considered that a large number of those who enter will have been in for the examination before—some more than once—and that a larger number still will be able to learn many of the particulars through their friends.

The publicity which has now for so many years been customary at all our Universities and great schools, as well for pass as for competition examinations, appears to be even more necessary in those for the managers of mines.

Again, in the case of an examination such as this, it is most impolitic to maintain any secrecy which is not absolutely necessary. There is no more effectual way of setting up the prejudices and exciting the suspicions of English working men, and probably Welsh as well, against any proceeding, than by observing any mystery in the mode of carrying it out.

It is, moreover, due to the examiners themselves, in all public examinations, that they should be able to show that there is a certain standard maintained by their papers, to which all who pass must have attained. It has always been found that this has been best secured by the papers being rendered public as far as possible.

The only reason which has been assigned for maintaining this secrecy, is that it will have the effect of checking "cram." Here the writer feels that he cannot too strongly bring before the notice of the Institute the grave mistakes which have resulted from not clearly considering the difference between true education and mere instruction, which is almost another word for "cram." Many of the most noble endeavours towards improving education have been marred by the office of the educator having been gradually usurped by the crammer, or by considering the test of results alone, instead of the training and habit of mind induced by the process of education. But to return to the point:—there is little doubt that if it were possible to maintain the perfect secrecy which is sought for, and if there were not other grave objections to this course, it would render difficult the office of the crammer. It is hoped it has been shown that such secrecy is utterly impossible, for "you may command men's bodies, but you cannot command their minds," and also that, if enforced, it would produce a greater evil than the one sought to be avoided; for, having shown that more or less information as to previous examinations will inevitably creep out—thus affording those who can get it the unfair advantage of "cramming" in the narrowest and most hurtful manner—the question arises whether the alternative method of extreme publicity (though giving, also, undoubtedly, certain opportunities for cram) does not, at the same time, by its very openness and impartiality, and by its guarantee of the judicious variation of the questions, also supply the most effectual corrective for that "cram" which must more or less be present in all such examinations.

This question has been all but universally decided in practice in

favour of publicity. What valid argument, then, can possibly be urged for going back to those enemies of progress—Mystery and Secrecy?

The writer now begs to submit this important matter to the serious consideration of this influential Institute, trusting that, after having come to a mature decision upon it, the members will not rest until some practical step is taken by them with the view of delivering the mining community of our land from what he cannot but regard as a serious evil.

Before the discussion commenced the SECRETARY read the following letter from Professor Marreco :—

College of Physical Science.

Newcastle-upon-Tyne. July 24th. 1874.

MY DEAR SIR,

It will be out of my power to attend at Cardiff, having to be at a Conference in London at the time. I observe, however, that it is proposed to petition *in re* "Examination Papers." So far as *we* are concerned, it would be certainly desirable that they should be published. We are at present entirely ignorant of how far our teaching bears upon these examinations. Were the other teachers of the College here, I feel sure they would endorse this opinion. I may just add, that even supposing it to be desirable to prevent their publication, I know, as a student, that it is impossible to prevent practically accurate copies from being circulated.

I am, yours very obediently,

A. FREIRE-MARRECO.

The PRESIDENT thought it hardly a subject that could be discussed with a view to any decision.

Mr. COCHRANE was of the same opinion as the writer, that nothing but evil can arise by preventing those papers from being made public. It is quite clear that if any advantage can be got from a knowledge of the previous examination papers, such information will get out. Those who undergo the examinations can certainly carry away nearly the whole of it, and it would, he thought, be better to publish it. He moved that the matter be referred to the Council for consideration as to what steps shall be taken.

Mr. E. F. BOYD thought that the question was of most vital importance. He would ask whether the word "cram" is applied so largely and so

differently to the questions of mining engineering as it is to that of literature. It seemed to him that a man so examined could hardly "cram" with information upon the questions that are likely to be put before him, and if publicity were to be given to them, the necessity of preparing for the answers to those questions would go beyond "cram," and a man must go to such trouble to get the information to answer the questions of the Committee as would entirely supersede the "cram."

Mr. SIMPSON said he had great pleasure in seconding Mr. Cochrane's motion, and thought it a very important subject which ought not to be overlooked. The examination should be one of a very particular character, because there ought to be no chance that a man who has never been down a pit in his life shall be able to pass it. He quite agreed that it is necessary that the subject upon which the candidates have to be examined should be known, but it required great consideration whether all the questions should be made known which have been put by former examiners. It had been discussed at the Northumberland Board, whether examinations should be public or not, but no decision had been come to upon it. Now that the question had been referred to the Council of the Institute, some definite conclusion may be arrived at.

Mr. JOHN DAGLISH, as an examiner under this Act, stated that the question now under discussion had been often before him. He had no opinion in the matter either way, but would say that the feeling of the majority of other Examiners was that the subject should be kept private. Candidates do certainly "cram," at present.

Mr. WRIGHT remarked that there are many men who go in for an examination, and do not go through it. Those men carry away as much as they can for their own use next time, and, even if they tell nobody else, they have it in their own heads. This cannot possibly be prevented. He had heard of a recent examination under the Mines Act, in which a large proportion of the students failed, and they would have an unfair advantage over the others in the next examinations. With regard to Mr. Simpson's observations as to this being comparatively a narrow subject, so that there might be a difficulty in varying the questions so as to keep up the paper test, he could scarcely conceive anything more varied than mining engineering. It embraces almost all branches of engineering, as well as of science, and a man ought to know a little of everything to be a mining engineer; and therefore it is capable of great variety. Then there is still the *viva voce* examination to supplement the paper—which nobody can publish, and that will do away with all possible objection to the suggestion of publishing papers.

The resolution was carried unanimously by the meeting, and a vote of thanks was given to Mr. Martin for bringing the subject forward.

The PRESIDENT said, that before they parted, he proposed that they should recognise the great kindness exhibited to them in this place by passing a resolution expressing their warm thanks to Mr. Thos. Forster Brown, the President of the South Wales Institute of Engineers, and the various gentlemen who had shown such hospitality, and who had so facilitated their proceedings.

This vote having been carried by acclamation, the meeting terminated.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, OCTOBER 3RD, 1874, IN THE
WOOD MEMORIAL HALL.

MR. A. L. STEAVENSON, VICE-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting, and they were confirmed.

The SECRETARY stated that at the Cardiff meeting Mr. R. F. Martin brought forward a subject with respect to the examination papers for those who had been examined for their certificates being kept secret. It seemed that the Home Secretary had issued a circular stating that the whole of these examination papers were to be considered confidential, and not to be published in any way; this was discussed at the meeting at Cardiff, and it was unanimously decided that the question should be left to be re-discussed before the Council, and this had been done to-day. Mr. Martin had very kindly attended, and the Council had now decided that Mr. Cochrane, Mr. Dees, the solicitor to the Institute, and the Secretary, should draw up a memorial to the Home Secretary, praying that this secrecy might be discontinued.

The SECRETARY then read the minutes of the Council meeting.

The following gentlemen were elected members of the Institute :—

MEMBERS—

Mr. WM. ELTRINGHAM, Clavering Place, Annfield Plain, Lintz Green.

Mr. C. J. POTTER, Heaton Hall, Newcastle.

Mr. W. MOOR, Engineer, Hetton Colliery, Fence Houses.

Mr. JAMES A. THOMPSON, Engineer, South Derwent Colliery, Annfield Plain,
Lintz Green.

Mr. W. RUTHERFORD, Milkwell Burn, etc., Collieries, Lintz Green.

Mr. J. D. KENDALL, Roper Street, Whitehaven.
 Mr. J. H. STRAKER, Willington House, Co. Durham.
 Mr. H. F. WILD, Rhinebeck, New York.
 Mr. W. DAKERS, Jun., Colliery Viewer, Birtley, Co. Durham.
 Mr. NATHANIEL THUBRON, Merthyr Dare Colliery, Merthyr Tydvil.

STUDENT—

Mr. W. H. TELFORD, Cramlington Colliery, Northumberland.

The following gentlemen were nominated for election at the next meeting :—

HONORARY MEMBER—

Dr. H. ALLEYNE NICHOLSON, Professor of Biology, College of Physical Science, Newcastle.

MEMBERS—

Mr. GEORGE MURRAY, Engineer, Sandhill, Newcastle.
 Mr. JOHN PATTISON, Engineer, Naples.
 Mr. JAMES BEAUMONT, M.E., Oughtbridge, near Sheffield.
 Mr. JOHN RIDYARD, M.E., Walkden, near Bolton-le-Moors.
 Mr. THOS. SUTHERST, Cleveland Iron Works, Guisbro'.
 Mr. DAVID DAVIS, Coal Owner, Maesffynon, Aberdare.
 Mr. ROBT. ABRAM SMITH, 74, Osmaston Street, Derby.
 Mr. RICHARD BLACKBURN, Bronwhlfa Colliery, Mold.
 Mr. JOHN COOKE, M.E., Wigan Coal and Iron Co., Wigan.
 Mr. DAVID W. ROBSON, Ouston, Chester-le-Street.
 Mr. DAVID GRIEVES, Brancepeth Colliery, Willington, Co. Durham.
 Mr. ROBERT JORDAN, Ebbw Vale, South Wales.
 Mr. CHRISTOPHER BAILEY, Heworth Colliery, near Newcastle.
 Mr. G. R. PALMER, Jesmond High Terrace, Newcastle.
 Mr. J. RICHARD HAINES, M.E., Adderley Green Colliery, near Longton.
 Mr. WM. MCCULLOCH, Cympermar Mountain Ash, South Wales.
 Mr. JAMES SMALLSHAW, M.E., Westleigh Colliery, Leigh, near Manchester.
 Mr. F. R. GODDARD, Accountant, Newcastle-on-Tyne.
 Mr. J. S. ELAND, Accountant, Newcastle-on-Tyne.
 Mr. J. G. BENSON, Accountant, Newcastle-on-Tyne.
 Mr. JAMES SPENCE, Manager, Clifton and Millgramfitz Collieries, Workington.
 Mr. WALTER MOSELEY, Electrical Engineer, 5, Strand Street, Liverpool.
 Mr. JOHN GARSIDE, Colliery Manager, Plashymaston Colliery, Ruabon.
 Mr. GEORGE THORNTON, Manager of Iron Works, Pen-y-bryn, Ruabon.
 Mr. THOMAS LIVESEY, Jun., Albert Lodge, Heaton Chapel, Stockport.

STUDENTS—

Mr. DUGALD S. MILLER, Wearmouth Colliery, Sunderland.
 Mr. ROBT. BLACKIE, Litherland House, Seaforth, Liverpool.
 Mr. JOHN S. CALDWELL, The Grove, Westhoughton, near Bolton, Lancashire.

Mr. CHAS. A. MOREING, Haydon Bridge, Northumberland.

Mr. J. C. WALTON, Heworth Colliery, near Newcastle.

Mr. J. E. WILLIAMSON, Harton Colliery Offices, Tyne Dock, South Shields.

Mr. JAMES DARLINGTON, Springfield, Wigan.

Mr. J. T. WILSON, Thornton Fields, Guisbro'.

Mr. T. H. STONES, Wigan Coal and Iron Co., Wigan.

Mr. CHAS. BARRETT, Harton Colliery, South Shields.

The SECRETARY stated that he had a letter from Mr. Lebour, stating that he was obliged to go to South Wales, and was therefore unable to read his paper that day.

Mr. R. S. NEWALL then read a paper "On Supplying Newcastle and District with Water from Lake Ullswater."

ON SUPPLYING NEWCASTLE AND DISTRICT WITH WATER
FROM LAKE ULLSWATER.

BY R. S. NEWALL.

THE vital importance of an adequate supply of pure water for the inhabitants of Newcastle and the neighbouring towns is so self-evident, that no excuse is required for taking the initiative in bringing the matter before the Institute of Mining and Mechanical Engineers. It is unnecessary to go into the history of the Newcastle and Gateshead Water Company, further than to state that they began work in October 1848, on the principle that the drainage of 4,340 acres, or less than seven square miles of land near Harlow Hill, was better than pumping water from the Tyne at Elswick, which their predecessors had done. They dammed the Whittleburn, and made reservoirs capable of holding 215 million gallons. The pipe conveying water to Newcastle was 2 feet in diameter, and capable of carrying about $4\frac{1}{2}$ million gallons per day. They ascertained that the rainfall was 24 inches per annum, and they estimated that half of that would find its way to the reservoirs, and produce $3\frac{1}{4}$ million of gallons per day, or equal to ten months' consumption at the then rate of 700,000 gallons per day.

In the dry year of 1850, they were obliged to resort to pumping from the Tyne to supply the demand—a practice which is continued to this day—but whether the new pumping station at Newburn has improved the quality of the mixture of water cannot be ascertained, as there are no analyses of the water taken at different times.

Some five years ago they constructed the reservoir at Hallington, which is capable of holding about 600 millions of gallons of water derived from drainage, but it is not clear that this has ever been filled. However, it is stated in a paper read by Mr. Main, the secretary of the Company, before the British Association, when it met in Newcastle in 1863, that in 1845 the number of persons supplied with water was 10,275 (representing a population of 100,000), and that they consumed

about 700,000 gallons a day. Now that the population has increased so much, and so many large manufactories use the water, the demand is about seven millions a day.

The water required for the supply of towns ought to be of the purest description, because pure water is necessarily soft. Soft water is more wholesome, it is more economical, and is more easily dealt with in household and manufacturing operations. Hard water is apt to produce calcareous diseases ; it renders washing of all kinds difficult and expensive, and it is a well-known cause of complaint in household and manufacturing operations that vessels and pipes for boiling water become furred up by deposits of lime, &c., which are difficult and very expensive to remove.

Comparing the water supplied by the Newcastle and Gateshead Water Company with that from Ullswater, the Newcastle water has about 20 degrees of hardness according to Clarke's scale, while Ullswater has 1·9 degrees ; so that, to produce the same effect in washing, Newcastle water would require ten times the quantity of soap, and even then, owing to the deposit of curdy matter at the beginning of the operations, it would entail much more labour, and the result would not be so satisfactory. Water containing nitrogenous matter is unwholesome. Ullswater contains no organic nitrogen, and only a very small percentage of nitrates and nitrites.

The whole of these points were fully discussed by the Royal Commission appointed to examine into the water supply for London, and a reference to the Blue-books on the subject, containing reports of the analyses of the various waters proposed, made by the first chemists of the day, shows that Ullswater appears to be the most desirable source from which to obtain such supply. The fact that it has been proposed to take its waters to London, at enormous expense, is the strongest proof of the good quality and quantity of the water. It was found impracticable to carry it over Shapfell, and therefore the alternative of tapping it at its southern extremity, by a tunnel, under Kirkstone Pass was proposed. This in extent and expense would well compare with the tunnel through Mont Cenis, except on one point, the one was only a proposal and the other is a reality.

Objections have occasionally been raised to Ullswater on account of the lead works near it. It has been, even lately, asserted that the waters are so poisonous as to kill the fish in the lake, and that therefore the water is unfit for human drink. This, however, is not founded on fact, and the writer will now discuss that part of the subject, because it is important to clear away at once and for ever such unfounded reports.

At the upper end of the lake, in the Glenridding Valley, are situated the Greenside Lead Works. The ore is extracted and washed on the spot, and the washing water runs down into the lake near to the Ullswater Hotel, where it forms in the lake a delta of considerable extent; so much so, that in August last, men were engaged in digging a trench through the mud brought down from the washings. That this lime mud may deter fish from frequenting the neighbourhood is conceivable, but that they are poisoned by lead dissolved by the water is quite incapable of proof; for galena is not soluble in water except it be perfectly pure, and even then in such very small quantities as to have no effect on human life.

The result of observations on the action of soft water on metallic lead when scraped bright, prove conclusively that the action ceases when the surface is tarnished (this is more especially the case when the water contains a considerable amount of carbonic acid), and that therefore no fear whatever need arise on this point.

The following analysis will show the purity of the water which it is proposed to bring to Newcastle.

Total solid residue in 100,000 parts of water evaporated, 3·626.

Mineral substances in 100,000 parts of water—

Lime	...	...	...	...	...	6·730
Magnesia	...	...	...	...	...	·200
Potash	...	...	...	...	...	·267
Soda	...	...	...	...	...	·356
Sulphuric acid	...	...	...	...	...	·879
Carbonic acid	...	...	...	...	...	·310
Silica	...	...	...	...	...	·160
Chlorine	...	...	...	...	...	·604
Ammonia	...	...	...	...	...	·003
Nitrogen, as Nitrates and Nitrites	...	...	...	...	...	·005

Organic substances in 100,000 parts of water—

Organic nitrogen	·000
Organic carbon	...	...	...	...	...	·067

Gases in 100 vols. of water—

Nitrogen	...	...	...	...	...	1·551
Oxygen	...	...	...	...	...	·747
Carbonic acid	...	...	...	...	...	·185
Total gases	...	...	...	...	...	<u>2·483</u>

Hardness in 100,000 parts of water before boiling

... 1·9

Do. do. after boiling

... 1·4

Action on bright lead

... Considerable

Do. tarnished lead

... None.

There are several very important points to be considered in establishing any water-works. The first is the nature of the surface on which the rain falls. If this be of such a kind that a considerable amount of rain must fall before any water is deposited in the reservoirs, then a great part of the rainfall, whatever its amount may be, is retained in the soil and is not effective. Whereas, if the surface be hard rock, such as forms a large portion of the Ullswater district, then a fall of rain produces an immediate effect on the reservoir. The second point is the quantity of rainfall. Comparing the two cases of the Newcastle water-field, and that of the Ullswater: in the Newcastle district, one of the driest in England, there falls about 24 inches of water per annum, and only about one-fourth of this finds its way to the reservoirs of the Company: in the Ullswater district there falls from 60 to 100 inches per annum, which rapidly descends to the lake.

In looking round for a supply to take the place of Whittle Dene, it is natural to seek the nearest sources, and Rothbury has been suggested over and over again, but the quantity to be obtained from that place is not enough to supply this district with all its towns and manufactories. Mr. Bateman lately proposed that Tynemouth should spend £170,000 in bringing water from Rothbury to that town.

From frequent visits to the lake district of Cumberland and Westmoreland, the writer's attention was called to the splendid deposit of water in Ullswater; but at first sight it appeared impracticable to bring the water to Newcastle without pumping.

A very careful and laborious examination of the Ordnance maps, on the 6-inch to the mile scale, showed that a canal could be made between Ullswater and Newcastle without incurring any very expensive engineering difficulties, the greatest in fact being about a mile of pipe in crossing the River Eden, and another in crossing the North Tyne. These, of course, in this age would be made of iron, but in ancient times they would have been beautiful aqueducts of stone. The general course of the conduit is indicated by a line on Plate XIII.

Ullswater, according to the Ordnance survey, is 477 feet above the datum level of mean water at Liverpool, and the highest part of Newcastle is 400 feet above datum. The distance measured is 78 miles to the Town Moor, which gives a fall of one foot per mile, which is more than sufficient for the purpose of water flow. In the Loch Katrine and Glasgow water-works the fall is 10 inches per mile, and in Mr. Bateman's scheme for carrying water from the Severn to London by open water-course, he proposed a fall as low as 6 inches per mile.

It is proposed that this scheme should be carried out by a Commission appointed by the various towns interested, who will undertake the management of the water supply for the district, and it is presumed they will have to buy the existing Water Companies at valuations.

The writer has not gone into an estimate of the cost of this scheme, because, until a survey is made of the line, this cannot be satisfactorily done. That is a work which should be undertaken by the towns on the route, and as it is absolutely imperative that steps should be immediately taken to ensure a supply of water, it is hoped that it will be done so as to enable plans to be deposited in time for the next Session of Parliament.

As to the expense, there is reason for believing that the canal will cost no more than £6,000 per mile at the most, or say £500,000. This would convey 20 million of gallons per day.

The Loch Katrine aqueduct cost £468,000 for $25\frac{3}{4}$ miles, but that was a most difficult piece of engineering ; 13 miles of it were tunnelled ; $3\frac{3}{4}$ miles were iron pipes ; and 9 miles of open cutting, mostly through rock, at an average cost of £18,000 per mile.

The Ullswater canal will encounter no such difficulties, and if it terminates at the Whittle Dene reservoirs near to which it passes, a distance of eleven miles is saved ; but it is doubtful whether this is advisable until the state of the pipes is examined.

Mr. Bateman's estimate for 4 feet diameter cast iron pipes is £10,800 per mile laid down ; and for an open water-course in brick and concrete, capable of conveying 108 million gallons per day, with a fall of only 6 inches per mile, his estimate is £12,000 per mile. While for the Duntreath section of the Loch Katrine water-works, which included four tunnels and eight aqueducts, besides stream crossings, drains, &c., the cost was rather less than £7 per yard ; and as there are 140,000 yards in 80 miles, this would amount to £980,000, which is far beyond what the present scheme ought to cost.

But suppose that the canal and purchase of the Water Company's works did cost a million, and that there are 400,000 inhabitants to benefit by it, the whole amount would be paid in two years by a contribution of 6d. per week from each.

It is now well recognised that all great projects of this and similar natures should be the property of the communities to whose necessities they minister, or in other words, that the consumers should be the proprietors of their own works, and guardians of their own interests.

Mr. NEWALL, in reply to Mr. J. M. Redmayne, stated that the Eden was 100 feet wide, and, in August last, had an average depth of three feet at the place whence it issued from the lake ; its velocity was as near as possible a yard a second, which would give some 500 millions of gallons per day. He had not made any minute survey or estimate, as he thought that duty devolved upon the local authorities interested.

Mr. J. DAGLISH asked Mr. Newall if his attention had ever been directed to Rothbury as a source of water supply ?

Mr. NEWALL said, of course he had been at Rothbury several times. As he had stated in his paper, the supply of Rothbury was quite inadequate to their wants. It might be enough to supply Morpeth or some of the neighbouring towns, but it was not nearly enough for Newcastle. There were springs at Rothbury issuing out of the millstone grit at an altitude of about 600 feet : the ground fell rapidly down to about 150 or 200 feet, therefore it would be necessary to bring the water from that district in pipes.

Mr. J. F. TONE stated that he had gauged the Tosson spring and found it yielded a quarter of a million gallons a day.

Mr. R. BURDON SANDERSON said he was sorry he had not been present at the beginning of the meeting, but it was not owing to any fault of his own, but to the fact that the express train was forty minutes late, and had kept him back. He understood that Mr. Newall had stated that the Hallington reservoir had not been filled. He would assure the meeting that gentleman had been misinformed, for the reservoir had been filled twice over at least. It was true that it was at the present time practically empty, as it was certain to be at the end of the season. Any one at all acquainted with water-works knew that this was the month in which the reservoirs ran down, not to emptiness absolutely, but proximately to emptiness.

Mr. R. F. MARTIN, Whitehaven, would like to ask Mr. Newall one question. He was himself living in the extreme west of Cumberland, and there they had the advantage of the water supply from the Lake Ennerdale, the water of which was as nearly as possible perfectly pure. The whole of the town of Whitehaven was supplied from it ; and he could only wish there was more of it available—not because there was not plenty of water in the Ennerdale lake and plenty of water running out into the river, but because the water which they could take from the lake was limited in quantity. He might state that at Whitehaven the water which came from the Ennerdale Lake was so beautifully soft that nobody cared for rain water ; in fact, the use of a water tub was quite exceptional, since everybody washed with the Ennerdale water, which was as good as rain water

but unfortunately the Ennerdale Lake had a proprietor, and he limited the supply which the town of Whitehaven might take to a certain number of gallons a day. The water at the end of the pipe was jealously watched and recorded, from time to time ; and they could not exceed their proper quantity. He had no doubt there was also a proprietor of Ullswater Lake. Most of the lakes, so far as he knew, had proprietors ; and no doubt this person would have power to act in the same way as the proprietor of the Ennerdale Lake. If this state of things existed in the case of the water supply to a West Cumberland town, he did not think Newcastle would be likely to be better treated. But he was stating lightly that which was really a most serious matter. In modern times, the question of individual rights and the convenience and necessities of the public at large became every day a more and more serious question. There was no difficult question of engineering in this scheme ; it appeared to be remarkably straightforward. He must congratulate Mr. Newall upon producing such a satisfactory plan in this respect. But really the question was—What would the proprietor of the Ullswater Lake say if the water were abstracted by Newcastle ; and what scheme would Mr. Newall advise to be adopted with regard to the private rights which he must necessarily interfere with ?

Mr. RICHARD CAIL said, he was old enough to recollect when the only water supply of Newcastle was from the ponds on the Town Moor ; and when the waterman went round twice a week and rapped at the door of such people as took the water, which was then allowed to run into their tubs for the space of about an hour. Companies had one after another succeeded each other. The one which was started to pump water from the Tyne at Elswick was thought to be of very great advantage, and an immense boon to the town ; at least so they were advised by the leading engineers of the day. The next place tried was the Whittle Dene ; and from time to time that company had been advised by engineers, some of whom stood at the very highest point in their profession, and they had expected to get a good supply, and with some reason, but in this year the supply had certainly failed very seriously, and the company had not been able to meet the demand, which was a great disappointment to them after receiving and paying for the best advice they could obtain. So far as Mr. Newall's scheme was concerned, when he heard of it he thought it was a desirable one, if it could be accomplished. He made a small tunnel for the old company of about two miles and a half in length through the Northumberland whinstone rock ; and he knew that tunnelling was very expensive and difficult. When Mr. Newall proposed

that scheme, and had shown by the contour lines on the large scale Ordnance maps that water could flow by gravity from Ullswater, he certainly must say he was astonished ; and he thought the greatest possible credit was due to Mr. Newall for the pains and labour he had taken in finding out those continuous levels. He thought Mr. Newall's estimate (£500,000) for the works would not be exceeded in practice, for he had carefully examined the maps, from which he considered ample data could be found to enable any practical man to give a shrewd guess at the cost.

Mr. C. G. GREY asked if Mr. Newall's attention had been called to what were called the Northumberland Lakes, which received a considerable area of rainfall, and were of large capacity for holding water.

Mr. NEWALL said, his attention had been called to them for some little time ; but, seeing that the supply to be obtained from them was so small compared to what they were able to get within a very short distance of them, and, believing the quality of the water was not so good as it ought to be, he had not troubled himself much about them.

Mr. GREY said, the lakes themselves had a constant quantity of water ; and from his own knowledge of them he was able to affirm that the area of some of them might be increased from 30 or 60 acres to 100 acres ; and their depth from 10 or 12 feet to 60 or 70 feet, which would, of course, materially increase the quantity of water they would contain. Some years ago, Mr. Bewick, engineer, of Haydon Bridge, had initiated a project for utilizing the water.

Mr. SANDERSON said, it might interest gentlemen to know that the company had in their possession at the present moment an estimate drawn by Mr. Bateman for bringing the water of the Northumberland Lakes to Hallington, at a cost, as far as he could recollect, of about a quarter of a million. Mr. Bateman said that the drainage there was not, in his opinion, sufficient ; and he had now before him a scheme for bringing water from a nearer point, at an estimated cost of about £300,000. It involved the construction of a new reservoir, at about twelve miles from the present reservoirs. He might mention, also, with reference to what another gentleman had said, as to riparian rights, that these rights were with all water companies a serious matter, and would very largely add to any estimate that was formed. He knew that the Glasgow Water Company purchased at a very considerable sum their rights to take water from Lock Katrine ; and he had reason to know from private information obtained since, that, if they were now to go to the Duke of Montrose and the other proprietors, the sum they would have to pay to take the quantity of water which they now obtain from Lock Katrine, would be a very

different one from the eleven or twelve thousand pounds they paid some years ago. He might also mention that the same restriction was put upon them as was put upon those who take water from Ennerdale—they were limited to a certain quantity. He believed it was 50 millions of gallons. The storage in the lake was calculated for a period of 120 days ; but he thought a storage of 160 days would have been more satisfactory. With reference to the survey which Mr. Cail had mentioned, it would be well to remember that in the present state of the law with reference to matters involving expenditure, it was wise to be cautious before any very great expense was incurred. In Edinburgh the trustees there four years ago determined to bring the water of St. Mary's Loch to Edinburgh. They went to Parliament, and backed by the three Town Councils of Edinburgh, Leith, and Portobello, whom they represented, they applied for their Bill, and first of all lost it. They applied a second time, he thought in 1870 ; they then gained their Bill in one of the Houses and lost it in the other. They thus involved themselves in an expenditure of £16,000 or £17,000 ; and the inhabitants, who knew it would impose a rate of from 6d. to 8d. in the pound upon them, not only beat them in the House, but prevented their imposing that £16,000 upon the rates which they had in hand for water supply purposes ; and from that day until last session, 1874, they had this sum of money standing at their personal cost. He believed they had now got powers by another Bill to pay it. The St. Mary's Loch scheme was found to be very expensive, the estimate being about £400,000 ; and the rateable value of Edinburgh was not only greater than that of Newcastle but nearly equal to that of both sides of the Tyne ; and they had to abandon St. Mary's Loch and to go to a much inferior scheme. He mentioned these matters because they distinctly indicated—first, that the consent of the corporations of three or four towns together was not sufficient if the inhabitants found that they were likely to have an additional taxation put upon them, and opposed them ; and, secondly, that those who go into these schemes and opposed them must be prepared, as he had no doubt they were, to pay out of their own pockets some £15,000 or £20,000 if they were unsuccessful in their undertaking. The experience of the directors of the Newcastle and Gateshead Water Company was, that at a time when it would have been very necessary not only for the Company, but also for the interests of both towns, to have had an extra rate of twopence in the pound, which really was a rate of 2d. upon perhaps 10d. or 11d., that rate was refused to them. The Company thought they had shown ground for its necessity ; and this had been one of the difficulties they had had to contend with.

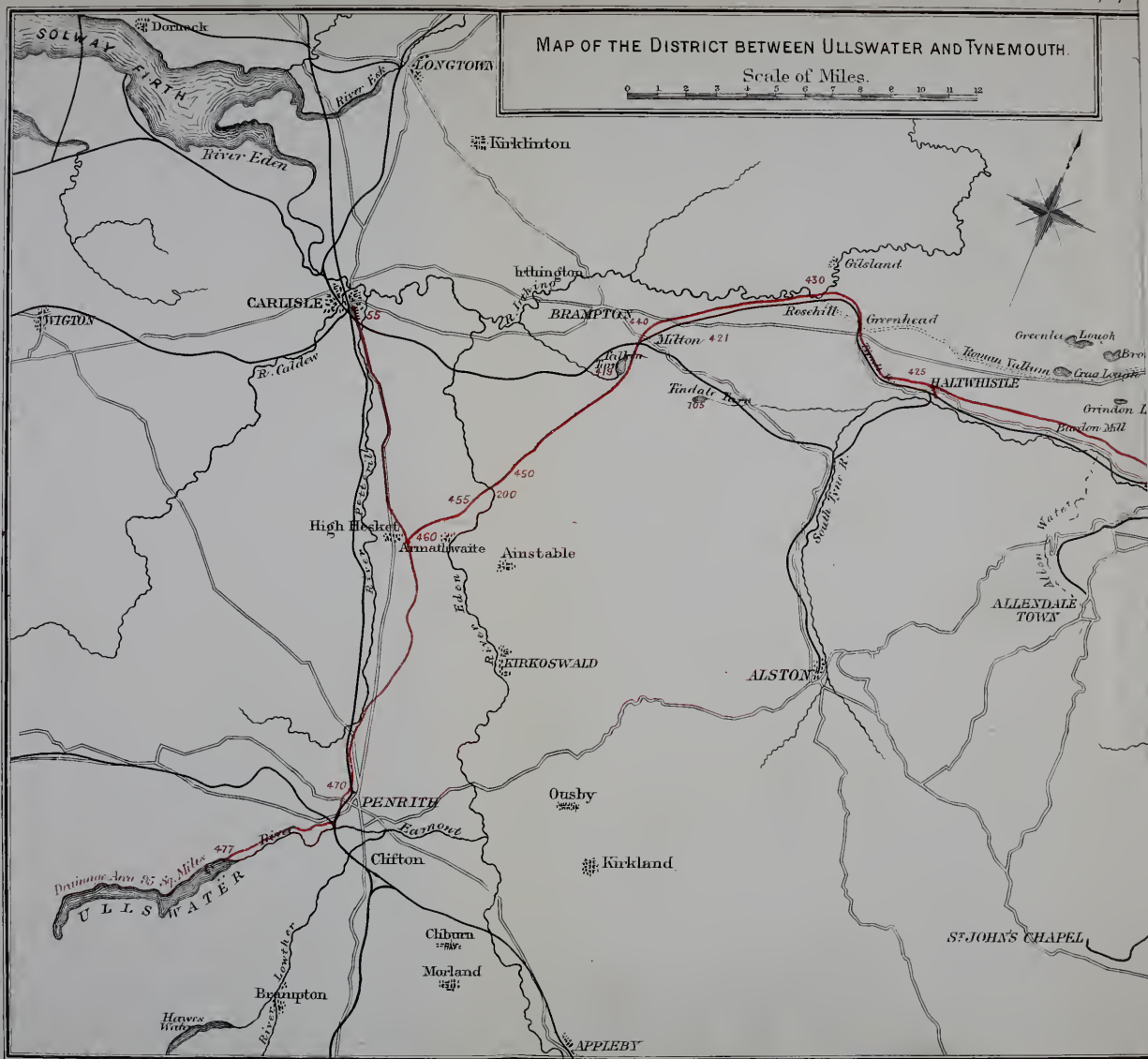
and was his reason for supposing that even though Mr. Newall's estimate, which had been mentioned as a million of money, was correct, it was improbable that an extra taxation of £50,000 could be obtained from the district. The first step was to buy up the other companies at present in the field; there was not one instance either in England or Scotland of two water companies supplying the same district—Parliament always requiring that the old companies shall be first of all bought up. He did not know whether the Sunderland Water Company was included in Mr. Newall's scheme; but supposing it was not, there were three-quarters of a million which would have to go in this shape in the first instance, and the taxation must of necessity include payment of the interest upon the sums awarded to those companies. As a question of engineering, he had never had the slightest doubt that Mr. Newall was right. He had not the slightest doubt, also, that his estimates would be greatly exceeded, from the knowledge he had of the various incidents belonging to water-works, which were only known to those who had practical experience of such matters; and he had not the slightest doubt, on the other hand, that the public in this part of the world would not pay for the necessary taxation, even for so important an article as water. The greater part of the difficulties which had arisen not only in this district but in all other parts of England this year (which difficulties had been far beyond anything which most persons were aware of), arose from the indisposition to be taxed. Manchester had been short; Liverpool, if not short at the present time, he believed had been short, and was constantly in a state of shortness; and both these towns had municipal water companies. Other places had been short, partly from their disinclination to pay rates, and partly from the fact that certain circumstances in connection with the weather last winter had arisen and had thrown engineering calculations quite out of the way. They were advised that in going to Hallington reservoir they would always have power to fill it. They could fill it with a very moderate rain-fall—a rain-fall, he believed, under four or five inches. They were advised that the calculation of rainfall was so small that although the district was undoubtedly not a wet one, they would always be enabled to fill it. The circumstances had been that during last winter—the six months during which all water companies depended to fill their works, they were only able to fill their old reservoirs to 500 millions—leaving themselves exactly in the same position as if they had not had Hallington at all. They acted on the best advice. He need not mention to any gentleman present that Mr. Bateman not only stood at the top of his profession in this country but at the top of his profession all over the

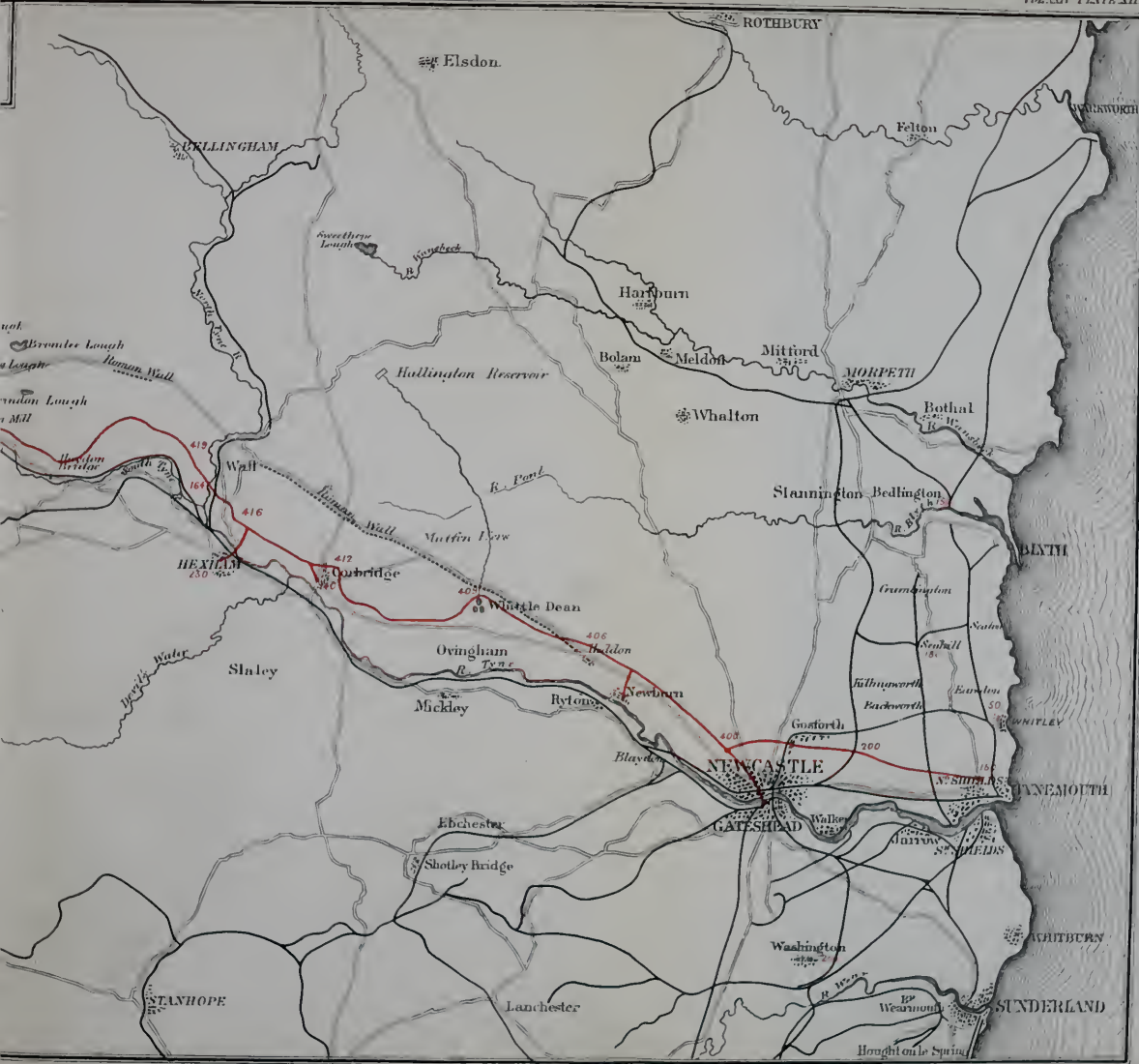
world. His practice in South America and his practice on the Continent of Europe was nearly as large as his practice in this country ; and he thought that when the Company acted by Mr. Bateman's advice, and had gone wrong when the seasons certainly had been most adverse to them, he hardly saw how they could be blamed in the matter. Some day or other, even at Glasgow, they might find themselves short. He had seen that in some seasons they had run very close upon the quantity they were empowered to take, which was measured by impounding the water up to a certain height. They calculated that they never would be 120 days without a moderate rain-fall. If the city drew too heavily, and the rain failed, and they drew down below the inlet to the works, then Glasgow would be in the position of having certainly a lake, but with the water at a lower point than that at which they could take it in. These were contingencies which might happen ; and he had heard Mr. Bateman say with reference to Glasgow that unless they were more moderate in their demands upon the water, they would find some day or other that wilful waste made woeful want. He did not wish to say anything further ; but according to the rules of the Institute this paper would be printed, and then they would have the opportunity of fully discussing it.

Mr. NEWALL said that Mr. Martin had put a question to him as to compensation for private rights. He was not able to answer that fully ; but he put the question to the captain of the steamboat on the lake the other day as to whether he paid anything for the right of navigating the lake, and he said "No, it was a public lake, and he paid nothing." Whether that would apply to the water which was passing out of the lake by the Eden, a small part only of which they proposed to take—whether or not they would have compensation to pay for that—he was not prepared to say. There were two mills outside the lake, and he did not think that the quantity of water, even if it should be twenty millions a day, which he proposed to take by and bye from that district, would interfere with their rights in any way ; there was plenty of water without it.

The CHAIRMAN said, the paramount necessity of having good water was quite apparent to every one ; how it was to be got at was of course more for the town to decide than for any one else ; but he thought they must all agree that they were very much obliged to Mr. Newall for the trouble he had taken in making the preliminary examination of the Ordnance map, and they could not do more now than propose that Mr. Newall have their best thanks for bringing this subject before them in the first instance. No doubt it would go to a larger and more

powerful audience than they were ; but Mr. Newall had done them the honour of bringing it before them, and he felt very much obliged to him, and trusted the members were of the same opinion. He then put the motion, which was carried unanimously, and the meeting separated.





PROCEEDINGS.

GENERAL MEETING, SATURDAY. NOV. 7TH, 1874, IN THE WOOD
MEMORIAL HALL.

MR. WILLIAM COCHRANE, VICE-PRESIDENT. IN THE CHAIR.

The minutes of the last meeting and of the council meetings were read.

The following gentlemen were elected members :—

HONORARY MEMBER—

Dr. H. ALLEYNE NICHOLSON, Professor of Biology, College of Physical Science,
Newcastle-on-Tyne.

MEMBERS—

Mr. GEORGE MURRAY, Engineer, Sandhill, Newcastle.
Mr. JOHN PATTISON, Engineer, Naples.
Mr. JAMES BEAUMONT, M.E., Oughtbridge, near Sheffield.
Mr. JOHN RIDYARD, M.E., Walkden, near Bolton-le-Moor.
Mr. THOMAS SUTHERST, Cleveland Iron Works, Guisbro'.
Mr. DAVID DAVIS, Coal Owner, Maesyffynon, Aberdare.
Mr. ROBERT ABRAM SMITH, 70, Osmaston Street, Derby.
Mr. RICHARD BLACKBURN, Bronwhlfa Colliery, Mold.
Mr. JOHN COOKE, M.E., Wigan Coal and Iron Co., Wigan.
Mr. DAVID W. ROBSON, Ouston, Chester-le-Street.
Mr. DAVID GRIEVES, Brancepeth Colliery, Willington, Co. Durham.
Mr. ROBERT JORDAN, Ebbw Vale, South Wales.
Mr. CHRISTOPHER BAILEY, Heworth Colliery, near Newcastle.
Mr. G. R. PALMER, Jesmond High Terrace, Newcastle.
Mr. J. RICHARD HAINES, M.E., Adderley Green Colliery, near Longton.
Mr. W. McCULLOCH, Cympermar Mountain, South Wales.
Mr. JAMES SMALLSHAW, M.E., Westleigh Colliery, Leigh, near Manchester.
Mr. F. R. GODDARD, Accountant, Newcastle-on-Tyne.
Mr. G. S. ELAND, do., do.
Mr. J. G. BENSON, do., do.
Mr. JAMES SPENCE, Manager, Clifton and Milgramfitz Collieries. Workington.

Mr. WALTER MOSELEY, 5, Strand Street, Liverpool.

Mr. JOHN GARSIDE, Colliery Manager, Plashymaston Colliery, Ruabon.

Mr. GEORGE THOMSON, Manager of Ironworks, Pen-y-bryn, Ruabon.

STUDENTS—

Mr. DUGALD S. MILLER, Wearmouth Colliery, Sunderland.

Mr. ROBERT BLACKIE, Litherland House, Seaforth, Liverpool.

Mr. JOHN S. CALDWELL, The Grove, Westhoughton, near Bolton, Lancashire.

Mr. THOMAS LIVFSEY, Jun., Manchester.

Mr. CHARLES A. MOREING, Haydon Bridge, Northumberland.

Mr. J. C. WALTON, Heworth Colliery, near Newcastle.

Mr. J. E. WILLIAMSON, Harton Colliery Offices, Tyne Docks, South Shields.

Mr. JAMES DARLINGTON, Springfield, Wigan.

Mr. J. F. WILSON, Thornton Fields, Guisbro'.

Mr. T. H. STONES, Wigan Coal and Iron Co., Wigan.

Mr. CHARLES BARRETT, Harton Colliery Offices, South Shields.

The following were nominated for election at the next meeting :—

MEMBERS—

Mr. JOHN PHILIP SPENCER, Borough Surveyor, North Shields.

Mr. EMANUEL DEFTY, Viewer, Wombwell Main Colliery, Barnsley.

Mr. RICHARD CLIFFORD SMITH, Bridgewater Trustees' Collieries, Parkfield, Swinton, Manchester.

Mr. F. E. SMITH, Engineer, Phoenix Foundry, Newgate Street, Newcastle.

Mr. T. SIBLEY WHITTEM, M.E., Wyken Colliery, near Coventry.

Mr. JAS. HOPTON, Colliery Manager, Killingbeck Colliery, near Leeds.

Mr. BRIAN B. WARD, M.E., Cliff House, Southwold, Suffolk.

Mr. JAMES FELLOWS, Great Wyrley, near Walsall, Staffordshire.

STUDENTS—

Mr. JOHN CROWDER EDGE, Ince Hall Coal and Cannel Co. Limited, Wigan.

Mr. EDMOND O. SOUTHERN, 1, Maple Street, Newcastle.

Mr. JAMES T. SHORT, Bedlington Colliery, Bedlington.

The meeting adjourned to the Theatre of the College of Physical Science.

The CHAIRMAN said, they were met there to hear a communication through Professor Marreco, written by Mr. Galloway. Perhaps as Mr. Galloway had done them the honour of being present there himself, it would not be out of order to ask him to read the paper, and then it would be left to Professor Marreco to conduct the experiments. This having been agreed to by the meeting, he called upon Mr. Galloway to read the paper and upon Professor Marreco to illustrate it.

Mr. W. GALLOWAY then read the following paper "On Safety-Lamps and Shot-Firing."

ON SAFETY-LAMPS AND SHOT-FIRING.

BY WILLIAM GALLOWAY.

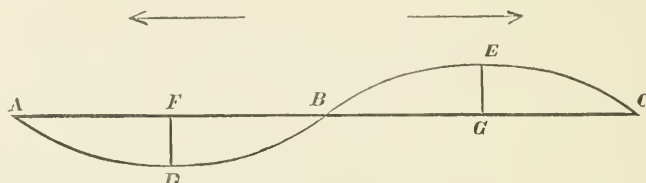
THE projection of a point moving uniformly in a circle upon a plane perpendicular to that in which the circle is described, executes *simple vibrations* in a straight line. The whole distance moved through by the projected point in one direction is called a *semi-vibration*; and the distance from the middle point to either extreme of a semi-vibration is called the *amplitude of vibration*.

When a piston makes *one* complete vibration of this kind in a tube of indefinite length filled with atmospheric air, it forms what is called an undulation (sound-wave, gas-wave, &c.) on each side; but for the sake of simplicity, it is proposed to consider only the wave formed on the side *towards* which the first movement is made. As the piston begins to move, it compresses the layer of air immediately in front, but the compression passes from the first layer to the next, and so on along the tube with the velocity of sound. So long, therefore, as the velocity of the piston is less than that of sound, it is plain that the *same* degree of compression to which the first layer is subjected at any instant, will at the next instant be found existing in one of the other layers, at a certain definite distance from the piston, along the tube.

The piston moves from rest, increases in velocity until it has reached the middle point of its course, and then decreases in velocity until it comes to rest at the end of the forward semi-vibration. When it is at rest in any position, the layer of air immediately in front of it (which may be conceived to be indefinitely thin) is uncompressed—that is to say, it is at the normal pressure existing in the tube before the vibration began; and when the greatest forward velocity has been reached, the same layer is in its state of maximum compression. When the piston moves in the opposite or backward direction, a rarefied wave is formed in a similar way to the condensed wave just described; but in this case the first and successive layers undergo a rarefaction which is greater or less at different points, according to the velocity of the piston.

The condensed wave, immediately followed by the expanded wave, traverses the tube, and each keeps its position relatively to the other.

In the following diagram, which illustrates the state of pressure in front of the piston after a complete vibration has been made, the piston may be supposed just to have reached the point A :—



The line A C represents the normal pressure in the tube ; the length of ordinates drawn to the curve A D B E C corresponds to the pressure existing in the wave at the points from which they are drawn. For instance, E G, at a distance of three-fourths of the wave length from A, gives the greatest compression or positive pressure, and D F, at one-fourth of a wave length, gives the greatest rarefaction or negative pressure. The lengths of the ordinates also give the relative velocities of the particles of air in different parts of the wave, and the arrows above the diagram indicate the direction of these velocities. At the points A, B, and C, the pressure is normal, and the particles of air are at rest.

The length of the abscissa, A C, depends on the *time* occupied by the piston in making a complete vibration, and on the *temperature* of the air.

Suppose, for example, the time or period of vibration to be $\frac{1}{200}$ of a second, and the temperature 50° Fahr.; then, since sound travels with a velocity of 1,110 feet per second in air of this temperature, the wave length, A C, = $\frac{1110}{200} = 5.55$ feet. In a second after the vibration has been completed, the end A of the wave will be at a distance of 1,110 feet from the piston ; the values of A C, F D, E G, &c., will not be sensibly changed ; each particle of the 1,110 feet of air between the wave and the piston will be in exactly the same position that it occupied before the passage of the wave, and have the same pressure and temperature ; the air at the points A, B, and C, will also be in a normal state as regards pressure and temperature ; but as regards *position*, the particles at B will have moved through a space equal to twice the amplitude of vibration, and every other particle of air in the 5.55 feet between A and C will be undergoing a change of position, pressure, and temperature.

As regards change of position, we have seen that the layer of air in contact with the piston was carried forward and backward when the

vibration was made—it had, perforce, the same velocity as the piston at different parts of its course, and its amplitude of vibration was also the same. But the different conditions of the first layer were immediately imparted to the second, and then to the third, and so on; and these conditions include a complete vibration, with a certain amplitude during the time required to produce a wave of the length λ . It is therefore obvious, that as the wave passes along in the tube, each layer of air through which it passes in succession, however distant from the piston, will vibrate to the same extent as the first layer, and its amplitude and period of vibration will also be the same. It is almost unnecessary, perhaps, to state that the tube is understood to be non-conducting, perfectly rigid, and perfectly smooth, and we need not here enter into the subject of a gradual dissipation of energy from other causes.

As regards change of pressure and temperature, each layer in succession is compressed, and consequently becomes heated above the normal temperature in the condensed wave. It is also rarefied and cooled below the normal temperature in the expanded wave. At the instant, however, when it emerges, so to speak, from the expanded wave, it resumes its original state in every respect.

The *length* of the wave is, within certain limits, independent of the amplitude of vibration; and the greater the amplitude of vibration, the greater is the amount of energy in the wave. In fact, the energy varies as the *square* of the amplitude of vibration.

When a blown-out shot is fired at the end of a gallery in a mine, a body of highly-heated gas rushes from the shot-hole, compresses the air in front and round about, and then condenses, producing a rarefaction. An irregularly shaped wave is formed: part of it is probably soon destroyed by dashing against the roof, sides, and floor, and being reflected again and again; but another part, meeting with no obstacle, proceeds along the gallery with a velocity depending for the most part on the temperature, and soon leaves the local eddies and indirect waves behind. This part, which is audible for a considerable distance, is the report of the shot; it has all the properties that have been described as belonging to a wave formed by the vibration of a piston in a tube. It will be remembered that one of these properties is to cause each layer of air through which it passes in succession to make a simple vibration, or rapid forward and backward movement, *without permanent displacement*.

Now, every one who has paid any attention to the subject must have observed that the flame of a lamp is instantly extinguished by an intense sound wave, while a less intense wave, or one coming from a great dis-

tance, causes it to dip, as it were, for an instant. In the latter case, however, it may be observed that the apparent dip is caused by an almost instantaneous deflection away from the origin of the wave, followed by as quick a return to the original upright position. From what is known, then, of the nature of a sound wave, it can only be concluded that the flame is deflected from and restored to its position while the layers of air, of which it forms a part, are being traversed by the wave.

As an illustration, we shall consider the case of a wave whose entire length is one foot, while the amplitude of vibration is one inch. Then, supposing the temperature of the air to be 50° Fahr., the whole wave will pass through each layer in $\frac{1}{1110}$ of a second. The condensed wave, however, passes through any given layer in $\frac{1}{2220}$ of a second, and during this period the whole of the particles of air of which the layer is composed have made a forward movement to a distance of two inches from their original position. The mean velocity of each particle of air in the condensed wave is therefore $\frac{2}{1110} \times 2220 = 370$ feet per second; and the maximum velocity is 581.2 feet per second. During the next $\frac{1}{2220}$ of a second, the layer is restored to its former position and condition by the passage through it of the expanded wave.

The celebrated physicist, Regnault, made some experiments to ascertain the distance from its origin to which a sound-wave will travel through air. He found that the report of a pistol charged with 1 gramme (15.43 grains) of gunpowder traversed a distance of 10,000 metres (6.21 miles), in the great conduit of the St. Michael sewer, before it became inaudible. The diameter of the conduit is 1 m. 10 (3.6 feet); the length was obtained by reflecting the wave, and thus causing it to pass over the same ground repeatedly. In conduits of smaller diameter the report from the same charge was much more quickly dissipated.

It is undoubtedly well known to every one present that when safety-lamps are exposed to a *current* of explosive gas, moving with a velocity of 8 to 10 feet per second and upwards, the flame is passed through apertures which it cannot penetrate under ordinary circumstances, and communicated to the external atmosphere. It has been proved, moreover, by the experiments of a committee of gentlemen appointed by the members of this Institute, that the more the velocity of the current is increased the shorter is the time it requires to act in order to pass the flame. In this case it appears that a preliminary superheating, as it were, of the substance in which the apertures are formed takes place, and that this circumstance partly accounts for the phenomenon.

Nearly three years ago the idea suggested itself to the writer that a

vibration of the explosive mixture in which a safety-lamp was burning, if its amplitude were considerable and its period small, might also cause flame to pass through wire gauze without the necessity of its being superheated beforehand. He was led to form this opinion from a consideration of the fact that a number of colliery explosions were known to have happened simultaneously with the firing of heavily-charged or blown-out shots. Accordingly a number of experiments in connection with the subject were made, and it was found that this hypothesis held true in the circumstances under which some explosions appear to have occurred, so far as these circumstances could be reproduced experimentally. Perhaps the most conclusive of all the experiments were those made in part of a new sewer in North Woodside Road, Glasgow. The section of the sewer is oval; it is six feet high, and four feet wide at a height of four feet from the sole. It may, therefore, be accepted as the representative of a small gallery in a mine. A safety-lamp with gas flame was placed on a board, fixed at a height of 2 feet 8 inches from the floor. The distance from the safety-lamp at which shots could be fired was limited to 109 feet in one direction, and 96 feet in the other. The shots were fired along the axis of the sewer, at the various distances indicated below, and the flame could usually be passed by the report or sound-wave of a pistol-shot, when the charges were as follow :—

At 27 feet from the Lamp	...	...	...	...	1·365 grammes.
54 feet	...	...	...	...	2·184 „
81 feet	...	...	...	...	2·730 „
96 feet	...	...	...	...	3·276 „
109 feet	...	...	...	...	3·822 „

One shot was fired with the barrel of the pistol pointing towards the roof at an angle of 70° to the axis of the sewer; the charge was 5·46 grammes; the distance was 109 feet; the flame was passed through the wire gauze and ignited the explosive mixture which surrounded the lamp.

For a more complete description of these experiments and most of the others that the writer made in connection with this subject, he would refer to No. 154 of the Proceedings of the Royal Society for 1874, where drawings of the apparatus employed and sections of the sewer are given in the plates that accompany the paper.

The CHAIRMAN said he was sure they would all agree with him in the importance of the paper that had just been read, and would be very glad to see all the proposed experiments tried. Did he understand that they

never had the Davy lamp in the sewer experiment at a further distance than 109 feet from the shot ?

Mr. GALLOWAY—Yes.

The CHAIRMAN said, that being the greatest distance at which Mr. Galloway had tried it, how could he draw the conclusion that the same result would follow in any part of a mine where the report could be heard ?

Mr. GALLOWAY said, they would observe that the charge was very small ; and the wave was not dissipated except very slowly. If they fired with a charge of 20, 30, 40, or 100 times the quantity, they might safely conclude that the sound wave would retain sufficient energy to pass the flame at relatively greater distances. The sewer experiments were simply illustrations of what might be done, just as this experiment was an illustration on a still smaller scale. The quantity of gunpowder used in this experiment was infinitesimally small.

The experiment which was now made, consisted in simply firing a pistol into two tin tubes about 3 inches diameter and 10 feet long ; these pipes were placed in the same line, but separated from each other by a space of about $1\frac{1}{4}$ inches. The barrel of the pistol was passed through a hole in a circular piece of wood, which exactly fitted one end of the first tube, the other end was open ; the end of the second tube, which was brought to within an inch and a quarter of the first, was provided with a diaphragm of thin India-rubber, protected by a metal guard, to prevent the wadding of the pistol from striking against it. The other end of the second tube was placed close to a lighted gas flame protected by a safety gauze, around which numerous jets of gas were escaping, and the object of the experiment was to show that the motion of the air produced by the pistol-shot and propagated in the second tube through the diaphragm was sufficient to drive the flame through the gauze and cause it to fire the external gas.

Mr. GALLOWAY said, that the experiment did not succeed if the charge of gunpowder was not exactly the quantity required ; an overcharge put out the flame ; and an undercharge did not pass the flame from the lamp. It required a certain quantity to do it.

Several experiments were tried ; one with a small charge of powder and the tubes close to each other, and a second with a larger charge, and the tubes separated by about an inch and a quarter, both of which caused the external gas to fire ; in the latter case the India-rubber diaphragm was observed to yield to the extent of about two inches. A large charge was then fired with the tubes close together, and the external gas was not

fired. This experiment was repeated in the dark with the same result ; all the experiments, therefore, were satisfactory illustrations of the paper.

The CHAIRMAN asked, if the powder was increased very much, whether the flame would be communicated to the external atmosphere and be subsequently extinguished?

Mr. GALLOWAY said, there appeared to be only a certain quantity which would pass it through. If they used above a certain amount the flame was extinguished.

The CHAIRMAN—Does it pass the flame and cause explosion, and then put it out?

Mr. GALLOWAY—It appears to do so.

Mr. NELSON asked if it was possible that the wadding might strike the diaphragm? This might cause a concussion of the air in the India-rubber diaphragm.

Professor MARRECO said, the guard was put in expressly to prevent such an occurrence.

Mr. NELSON said, that although the wadding was prevented from striking the diaphragm, he should imagine that it would, owing to its size and the speed it must travel at, carry a considerable amount of air with it, and also propel an amount of air violently in front of it, and that might deflect the diaphragm to a considerable extent, and cause the air to travel in front of it. The wadding would, he imagined, act as a piston.

The CHAIRMAN asked Mr. Nelson if his observation would not be answered by the fact that when the pistol was directed, as in the sewer experiment referred to in the paper, at a considerable angle to the axis of the sewer, the same effect was produced; and that therefore, although the observation might apply to the present experiment, it could not apply to the large experiment in the sewers?

Mr. WALLACE would like to ask the lecturer if he could offer any explanation of the mechanical effect of the movement of the air upon the flame, either to extinguish the flame or to pass it through the gauze? There were probably two ways in which the explosion might affect the flame; one was probably mechanical, and the other chemical. It had been explained that one of the effects of the explosion was to condense the air; and they knew that the effect of condensed air was a very remarkable one upon flame in general. Then again, there was the movement of the air, which might possibly have the effect of simply carrying the flame of the gas during combustion away from the position where the gas was being produced, that was the wick: and his question was whether it was

principally due to removing the flame from its source of maintenance, or whether it was the compression of the air which effected it. Of course the compression took place before the rarefaction ; and it might be that it was the compression, if the air was compressed, which had this effect upon the flame. Of course, the question naturally followed, what was the best form of lamp to prevent an explosion having this action upon the flame ?

Mr. GALLOWAY said, as to the flame being removed by the compressed air, the former part of his paper was intended to show the effect the shot had upon the air ; and he considered this an answer to the question of Mr. Wallace.

The CHAIRMAN confessed that the paper was too elaborate for him to understand at a mere reading, and required careful study. Probably other gentlemen had not fully comprehended it.

Mr. GALLOWAY said, the Chairman had answered Mr. Nelson's observation with respect to the diaphragm by saying that the experiment in the sewer entirely proved that the wadding had nothing to do with passing the flame.

Professor MARRECO—Besides, it was perfectly easy to produce all these effects with an explosive mixture of gases where there was no wadding at all. The earlier experiments detailed in the Royal Society's Proceedings were made with an explosive mixture contained in a soap bubble.

The CHAIRMAN said, they were glad to have seen the experiments illustrative of a paper showing so much original research, and throwing so much light on the important matter of explosive gases. It was only by such scientific research that they could obtain these valuable results. He could not, however, refrain from the observation that there must necessarily be a great difference between the result of such small experiments as those they had witnessed here, and the somewhat larger ones made in the sewer, and the conditions obtaining in actual practice in a mine. They were all much obliged to Mr. Galloway for his paper : and he begged to move a vote of thanks to him.

The motion was carried by acclamation, and the meeting terminated.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, DECEMBER 5TH, 1874. IN THE WOOD
MEMORIAL HALL.

R. S. NEWALL, ESQ., IN THE CHAIR.

The SECRETARY read the minutes of the last meeting, and reported the proceedings of the Council.

The following gentlemen were elected :—

MEMBERS—

- Mr. JOHN PHILIP SPENCER, Borough Surveyor, North Shields.
- Mr. EMANUEL DEFTY, Viewer, Wombwell Main Colliery, Barnsley.
- Mr. RICHARD CLIFFORD SMITH, Bridgewater Trustees' Collieries, Parkfield, Swinton, Manchester.
- Mr. THOMAS E. SMITH, Engineer, Phoenix Foundry, Newgate Street, Newcastle.
- Mr. THOMAS SIBLEY WHITEM, M.E., Wyken Colliery, near Coventry.
- Mr. JAMES HOPTON, Killingbeck Colliery, near Leeds.
- Mr. BRIAN W. WAND, Cliff House, Southwold, Suffolk.
- Mr. JAMES FELLOWS, Great Wyrley, near Walsall, Staffordshire.

STUDENTS—

- Mr. JOHN CROWDER EDGE, Ince Hall Coal and Cannel Co. Limited, Wigan.
- Mr. EDMUND O. SOUTHERN, 1, Maple Street, Newcastle.
- Mr. JAMES T. SHORT, Bedlington Colliery, Bedlington.

The following were nominated for election at the next meeting :—

MEMBERS—

- Mr. JOSEPH THOMPSON, M.E., Manvers Main Colliery, Rotherham.
- Mr. PETER W. PICKUP, M.E., Dunkenhagh Collieries, Accrington, Lancashire.
- Mr. JOHN GREENER, Albion Mines, Nova Scotia.

Mr. REGINALD WIGRAM, Steam Plough Works, Leeds.
Mr. JOHN H. COX, 10, St. George's Square, Sunderland.
Mr. GEORGE FRANKS, M.E., Victoria Garesfield, near Blaydon.
Mr. GEORGE CHARLTON, Washington Colliery, County of Durham.

STUDENTS—

Mr. ARTHUR C. MANN, Seaham Colliery, Seaham Harbour.
Mr. EDWARD AUBONE POTTER, Cramlington House, Northumberland.

Mr. G. A. LEBOUR, F.G.S., read the following paper:—On the “Little Limestone and its accompanying Coal in South Northumberland.”

ON THE "LITTLE LIMESTONE" AND ITS ACCOMPANYING
COAL IN SOUTH NORTHUMBERLAND.

 BY G. A. LEBOUR, F.G.S. LONDON AND BELGIUM, F.R.G.S., &c.

THE coals of the Carboniferous Limestone series in the North of England must eventually acquire a much greater commercial importance than they have hitherto had. As the Coal-measure seams become exhausted, the thinner and inferior, but by no means always bad, coals of the West of Durham and Northumberland will be sought after and worked; and the writer ventures to say, that it will be found that they are more numerous, thicker, and of better quality than they are usually supposed to be. It is as a small contribution to a more extended and accurate knowledge of these lower carboniferous seams that this paper is brought before the Institute. It is based entirely on personal observation and on authoritative documents, and so far as it goes, may, it is hoped, be found useful in future investigations.

The coal seams in the Carboniferous Limestone are too numerous to be all mentioned here, and many of them are too unimportant for detailed notice; they can, however, be conveniently divided into *five* groups (as far as the southern half of the county is concerned), which for convenience are named as follows in ascending order:—

1. The Lewisburn Coal Group.
2. The Plashetts Do.
3. The Redesdale Do.
4. The Shilbottle Do.
5. The Acomb Do.

It is with the most important seam of the last, or Acomb group, that the writer is now engaged. In a former paper,* he gave a brief account of the third group.

The position of each seam in the series of shales, sandstones, and limestones of every thickness, which constitute the Carboniferous Lime-

* Trans. N. of England Inst. Min. Engineers, XXII., p. 111, 1873.

stone series in the North of England, is best determined by ascertaining its relation to some well-known or easily-traced bed of limestone, either above or below it. By coal miners in the west this is so well understood that in many cases the seam takes the name of its "guiding" limestone. Thus the coal seam about to be described is often known as the "Little Limestone coal." This "Little Limestone" is a very constant stratum, recognizable over a large extent of country, from the Alston mining district to Coquetdale, and no doubt still further north, Plate XIV. In Westgarth Forster's section* it is described as being the second limestone of his "Lead Measures," the first being the "Fell-top Limestone," and the third the "Great Limestone." This arrangement holds good for a great portion of the south-westerly extent of these beds, but on reaching the Tyne a great change is discoverable; not, it is true, in their relative positions, which are tolerably constant throughout their known course, but in the appearance, between the "Fell-top" and the "Little" limestones, of three other calcareous beds, quite as important in thickness and in quality as the best of our Northumbrian limestones. The writer does not know these interpolated beds south of Corbridge, but from that place to as far north as the Wansbeck at least, they form conspicuous characteristics in the geological features of the country—more especially is this the case with the two upper beds, which appear to be more constant than the third and lowest one. The latter varies exceedingly in thickness, from twenty-five to five or six feet in three or four miles in some places. This putting in of additional limestones in a well-known series has been, probably, the cause of much of the misapprehension which has often prevailed with regard to the identity of the beds below them. The three limestones in question are well seen in the neighbourhood of Belsay, where the upper two are, or have been, largely quarried—the highest in the South Park, and the next in the North Park; the third and lowest is very thin here, but can be seen cropping out in the Belsay Burn, west of the park, just south of the Military Road; however, near Matfen Moor, this bed is fairly thick, and has been quarried. Before leaving the subject of these, so to speak, *extra* limestones, the occurrence of two thin seams of coal, in connexion with them, should be mentioned, with the continuity of which the writer is not acquainted; both have been worked, however, on a small scale—the upper one, about twenty inches thick, and lying immediately below the second of these limestones, at the Gallow Hill Quarry, near Bolam, and the lower, about eighteen inches

* "A Treatise on a Section of the Strata," etc., by Westgarth Forster, 1821, p. 165.

thick, and about forty feet below the third limestone, near the spot mentioned above by the Belsay Burn.

A considerable but varying thickness of strata occurs between the lowest of the intercalated limestones, and the "Little Limestone," not less than 1,250 feet in the Matfen and Inghoe district. The thickness between the Fell-top and the Little, would here be about 1,450 feet. In the Alston region this great mass is reduced to little more than 330 feet. This important thickening of this set of beds, together with the addition of the calcareous elements above described to the north-west, does not seem to have been pointed out before; but it agrees thoroughly with the gradual change of the entire lower carboniferous series from south to north. Accompanying this general thickening of the mass of strata above the "Little Limestone," there is a very obvious disproportion between the increase in thickness of the shales and that of the sandstones, of which this mass consists:—in the south-west, the total thickness of the sandstones is nearly equal to that of the shales, the latter predominating slightly, while on the other hand to the north-west, the shales form scarcely one-fourth of the entire mass. The sandstones moreover grow more and more gritty to the north-west, and are in places almost conglomerates. Thus at Inghoe Crag, Shafthoe Crag, and Rothley Crag, quartz pebbles are commonly found in the coarse grit larger than pigeons' eggs. Practically, indeed, from the Tyne to the Wansbeck the beds overlying the "Little Limestone" may be considered as one great deposit of sandstone, varying in texture from fine flagstones to the coarsest grit, and divided by bands of shale of no great thickness. One seam of coal at least there is in this series of grits, which in the Alston district is about four feet thick, and lies about half-way down between the "Fell-top" and the "Little Limestone," and which the writer is inclined to identify with the Oakwood Coal of St. John Lee, and Fallowfield, with some little doubt however. At the latter places the depth from the Oakwood coal to the "Little Limestone" is about 260 feet.

In the district under consideration, which may be roughly defined as extending from the South Tyne about Haltwhistle, to the Wansbeck about Wallington, the grit series can be easily studied, dipping at a low angle to east from the Wansbeck to Matfen, thence bending round towards Stagshaw Bank, and (except in faulted areas for short distances) keeping a westerly strike with a somewhat higher and southerly dip to beyond Blenkinsopp Castle on the borders of Cumberland. The isolated Warden Hill, and the long slope from the Roman Wall to the Tyne extending from Acomb to Corbridge, are formed of them, as are also (with a northerly

strike) the broad areas between Matfen and Stamfordham, and between Capheaton and Belsay. The whole range is marked by step-like lines of scarps and crags, the escarpments of course all facing the west. Between Matfen and Stamfordham the craggy nature of the series is least shown, owing to the old valley of the Pont being filled up by a very considerable thickness of drift clay and sand.

The "Little Limestone" is usually separated by a bed of shale from the last-mentioned grits, the thickness of which shale varies from 8 to occasionally over 30 feet. The limestone itself is very constant in its thickness, being 9 feet at Alston, 9 to 13 feet at Blanchland on the Derwent, 16 feet at Acomb, 17 feet at Matfen, and 16 feet at Inghoe. Considering the distance, these variations are very insignificant, but even with regard to this bed, the rule seems to hold of new beds wedging in towards the north for, as will be seen in the sections in Plate XV., a thin parting of shale makes its appearance in the Stagshaw Bank section, which gradually increases in the Matfen section, and in the two given of the Fenwick borings. The character of the limestone is that of the average fairly good calcareous beds of the district; it is seldom burned for agricultural purposes, but is frequently quarried for road metal. It is of a blueish grey colour when newly fractured, and weathers a reddish brown, but not so red as many of the other limestones. In the Alston district, it has been found very productive of lead, but the author is not aware that north of the Tyne this has ever been in any degree its character, unless it be so to a very limited extent at Fallowfield, where it reaches its greatest measured thickness, 18 feet. The line of outcrop of this limestone is so intimately connected with that of its accompanying coal, that the range of both will be considered together after describing the characteristics of the latter. Immediately below the "Little Limestone" in the Alston district, comes a shale some 20 feet thick which is, however, anything but constant; in the Derwent district it dwindles to 2 or 3 feet, it is absent altogether at Bardon Mills, is represented by about 25 feet of "grey beds" or arenaceous shale at Acomb, thinning to 12 feet at Fallowfield main shaft, and to scarcely a foot of shale a mile further; at Stagshaw Bank Colliery it is replaced by a sandstone 8 feet, with a shale below it 7 feet thick; at Matfen it has again disappeared altogether, but it reappears a little to the north-west as a slowly increasing band of shale in the Fenwick sections; at Inghoe it is 45 feet thick.

Below this shale in the Alston section there is the upper seam of the "Little Limestone Coal," about 3 feet thick; at Sheldon, Bardon Mills, and Matfen, it lies directly below the limestone; in the other sections given

it lies below the shale as at Alston or below its representative, the distance between the limestone and the coal varying from nothing to 30 feet. This top seam is, it is believed, invariably present in the south-western sections, and as far north and east as Bardon Mills at least. It is absent at Acomb as a separate bed, and likewise at the westernmost Fallowfield section; thence it is again found separate at the second section near that place, at Stagshaw Bank and at Matfen; at Fenwick, Inghoe, and as far north as the writer knows it, it is absent.

Except at Matfen, where a shale bed underlies it, the top seam is succeeded either by sandstone or by that arenaceous kind of laminated rock known by sinkers as "Grey beds;" the arrangement at each place will be seen by referring to the sections in Plate XV. The thickness of these intermediate beds varies from nothing (as at Acomb, Fallowfield shaft, and Fenwick), to about 25 feet (as at Stagshaw Bank).

The lower seam, where it is separated from the upper, is in some cases (as in the Alston district) thinner than it, but it thickens a little to the north-east, when it is generally about double the thickness of the top coal, as at Bardon Mills, Stagshaw Bank, and Matfen. Where the top coal is absent as such the thickness of the lower seam is much increased as at Acomb and Fallowfield; west of the latter place, however, where the top coal is present as a separate seam, the bottom seam is divided by five or six feet of shale into two parts, the lowest of which is the thinnest. This is the only place the writer knows at which three seams are found on this horizon, though such an arrangement may very probably obtain elsewhere.

There are two ways of accounting for the various relative positions and thicknesses of the seams: the one being that the top coal is an independent bed frequently thinning out altogether for a space and reappearing. Although this opinion may be held by some, yet it is submitted that a glance at the sections placed in juxtaposition, as in the diagram, will show that the real explanation is that the "Little Limestone Coal" as a whole, is split into two seams very usually, and into three seams *sometimes* by the intercalation of beds of shale and sandstone of no great thickness. That this is so is supported by the fact that where the seams are separate the sum of their thickness is pretty nearly equal to the thickness of the seam where it is single. Unfortunately no sections are known which show any of the actual points of junction of the upper and lower portions of the seam.

It does not come within the purposes of this paper to describe in detail the beds lying below the "Little Limestone Coal," between it and

the well-known "Great Limestone," but it should be noted that the thickness of these beds is quite as variable as that of those above, perhaps more so. Among these beds shale greatly predominates in almost every locality known to the writer, the chief member being a bed of black shale which immediately overlies the "Great Limestone," and which is very well developed and exposed in the large Fourstones quarries. Above this shale-bed, between it and the coal is, in the Acomb and Haydon Bridge districts at least, a thin bed of limestone which, where it is known, may serve as a guide to the coal. This little stratum was pointed out to the writer for the first time by Mr. Benson, of Allerwash, and might be very easily overlooked, as it is too thin to form a feature on the surface, and very few pit sections or borings range to below the coal. The only places where the writer has seen this limestone are the bed of the South Tyne, below Allerwash, and that of Silly Burn, on the north side of the main river east of Haydon Bridge.

The run of the outcrop of the "Little Limestone" and its coal is not difficult to trace in the district to which these remarks refer. From Blenkinsopp to Beamwham (faults of no very great throw being here unnoticed) the strike is nearly east and west, near the latter place a large fault, having a very considerable downthrow to the west, throws these beds up to the south side of the South Tyne, whence the dip and the shape of the valley bring them once more on the north or left bank, just at the east end of Haydon Bridge; thence to a little below Allerwash the outcrop keeps clear notwithstanding large accumulations of clay and gravel. At the latter place the beds are exposed by the river, which they cross, and with a gently-curved line on the south side come once more, for the last time, to the north bank at Fourstones. From Fourstones, skirting the northern flank of Warden Hill, the crop wends its way, crossing the North Tyne close to Wall Mill, following the base of Wall Crag, and reaching the Military Road at Planetree. Just north of St. Oswald's chapel our line is stopped by a dyke of basalt, which, being a filled-up fault, throws the beds up to the east some 50 feet; this brings the "Little Limestone" on to the road again, where it forms a great spread running to the south (the ground being here a dip-slope) between the whin-dyke and Hill Head; at the latter place a small fault running at right angles to the dyke again throws the beds a little up to the east, that is still more south of the road, between Coldlaw and Greenfield; the strike now begins slightly to bend to the north-east, and the "Little Limestone" is again brought on to the Roman road, where it forms another spread along the western side of the Great Fallowfield vein, which

is here nearly at an end both as to length and throw.* This vein or fault throws down to the east, and the outcrop of both coal and limestone now runs a little south of east (but with a S.S.E. dip) between Grottington and Stagshaw Bank. A little to the east of the toll-bar a fault again throws *up* the limestone to the south side of the road at Halton Shields, where it is largely quarried, and half a mile further yet another fault, with a throw the reverse of the last, throws the beds *down* to the east due south of Great Whittington. Here the dip is south-easterly, and as it very soon changes to almost due east, the strike from this point may be said to be due north as far as the Wansbeck. The outcrop through this district is, as has been noticed previously, very well marked, lying as it does at the foot of the bold encarpment of the overlying grits, which are rarely interrupted in that distance. No fault of importance crosses its path, and one basaltic whin-dyke only slightly throws it down to the north-west, about a mile south of Capheaton. The amount of dip between the Pont and the Wansbeck is on an average about four degrees or less, seldom rising to five degrees, and not unfrequently being not more than three degrees.

The "Little Limestone" and its coal are both of them known in that portion of South Northumberland which lies to the south of the Tyne, but the writer has purposely abstained from entering into that part of the subject, as he would have been unable to speak authoritatively with regard to it, his acquaintance with that much-faulted and very difficult part of the country being but limited.

He has thought it unnecessary to give the range of the strata described in a map as this will be found delineated with great care in the published maps of the Geological Survey. However, such diagrammatic horizontal sections have been given as may help to a clearer view of the stratigraphical relations of these higher beds of the Lower Carboniferous series as they appear in a large portion of Northumberland.

Besides the local details which, however dry and uninteresting, will it is hoped be found valuable by mining men, the chief points which the writer has endeavoured to bring forward in this paper are:—1st. The exact position of the "Little Limestone" and its coal with regard to the

* This crossing and recrossing of the site of the Roman way by the "Little Limestone" has puzzled former observers who were unable to make an extended examination of the country to the north and south. Thus the late Mr. George Tate, in his "Geology of the Roman Wall," appended to Dr. Bruce's magnificent work, has mistaken the reappearances of this limestone for the outcrops of different successive beds, and he has drawn them as such in the map which accompanies his memoir.

“Fell-top Limestone” on the one hand and the “Great Limestone” on the other. 2nd. The great thickening of the mass of beds lying above the “Little Limestone” which takes place from south to north and is accompanied by the interpolation of at least three new beds of limestone which are unknown in the Alston district, and by an increase in the coarseness of the grits themselves. 3rd. The division of the “Little Limestone Coal” commonly into two and occasionally into three seams.

The CHAIRMAN said, he would be glad to hear any remarks on that very interesting paper.

Mr. T. J. BEWICK said, it must be satisfactory to the members of the Institute to find a gentleman in Mr. Lebour's position, coming forward to give information, and aid them in their investigations into the geological features of the district. Mr. Lebour, he believed, up to a recent date, had opportunities which few of them enjoyed, and had been at liberty to go where he chose and leisurely scan the ground. It was rarely the lot of any of them, as mining engineers, to have that opportunity, and, therefore, Mr. Lebour was what might be called a link between one professional man and another; and, personally, he was extremely glad that Mr. Lebour had come forward with that paper. Parts of the district and the coal seam to which Mr. Lebour referred, were well known to him, and with most of what Mr. Lebour had said, he entirely agreed. It was not a remarkably uniform bed of coal; for, as Mr. Lebour had mentioned, it was occasionally divided, and not unfrequently was very puzzling to those who had to develop it. The same thing occurred with reference to the other strata to which Mr. Lebour had alluded, which were found, in one part, thickening, and, in other cases, thinning and dividing, and until a series was obtained, or perhaps one or two beds of different rocks which could be well identified, it was most difficult to recognise them. He had, at that moment, in his own experience, a case in that very field, in which he could not say he was quite satisfied that he knew in what bed of limestone he was working. The investigations of Mr. Lebour were probably extended to fields beyond his (Mr. Bewick's) observation, and, therefore, perhaps he would be able to define it better than he (Mr. Bewick) could do. So far as he had been able to make out these several rocks, even the “Great Limestone” itself, which was one of our most uniform beds, he knew from actual experience, were divided in the northern part of the field. In Alston Moor, in Allendale and Weardale, in Teesdale,

and into Yorkshire, it was one uniform bed, seldom less than nine fathoms, and rarely, if ever, more than twelve fathoms thick, and, therefore, a bed, which of all others, could be traced, and it had a peculiarity in it which few of the others possessed, and that was, that at about 20 or 24 feet from its top, there was what was called the "black bed," a stratum of shale. This applied with remarkable exactness over the field he mentioned; but in Tynedale, the same peculiarity does not occur; and his impression at that moment was that this black bed, which was rarely more than two feet in the lead-mining districts proper, increased in thickness north from Allendale. At Whitfield Hall, for instance, it was, he believed, about 20 or 24 feet; perhaps Mr. Lebour could correct him if he was wrong, but certainly it was more than 18 feet. Farther north, the thickness increased; and he should not be surprised to find in Tynedale, that, in addition to the shale, there might be sandstone, or what, in mining phraseology, may be called a grey bed, which is an arenaceous shale. He thought they would find in Tynedale, all round this very district which Mr. Lebour had described and illustrated, that the great limestone of the lead-mining districts is divided, and does not maintain the same characteristics which it has in Alston, Allendale, Weardale, and Teesdale. He had had some opportunity of judging of these same mountain limestone beds in the north, towards Little Mill, and in that neighbourhood, and also in some of the intervening places, but he had not traced them right through; yet he might say that he was unable to recognise the beds of Little Mill and those in Tynedale. Another point, he might mention, occurred with reference to those same limestones further south. In the southern part of Yorkshire, Wharfedale, and towards Skipton, they are found just exactly the reverse of what occurs here. Here, in the north, the shales and sandstones predominate; in the south, at the places he had mentioned, the limestone does so. He believed he was correct in saying that in the southern part of Wharfedale, in the neighbourhood of Coniston and Kettlewell, there is a thickness of about 2,000 feet of limestone—almost continuous—with mere films or thin divisions of shale. There was no doubt these were the same limestones which are here, and which pass through all the mining districts—the mountain or carboniferous limestone. There was a gradual change in passing from one part of the island to another, although, geologically, they were the same formation.

Professor PAGE said, that this gradual thickening of the carboniferous limestone to the south and south-east, and its thinning and breaking up into several beds to the north and north-west, had been long ago

noticed, as Mr. Bewick was aware, by Mr. Hull, who attributed the fact to the deep sea water being to the south and south-east, while towards the north and north-west, the shoal or shallow water was approached. Another reason which Mr. Hull did not sufficiently allude to was, that in Northumberland, and particularly in the Scotch coal-field, there were a great many limestones occurring, interpolated and broken through by the trap-rocks increasing to the north-west and north, showing that volcanic action had been going on, interrupting the continuity of the calcareous beds, while no change was taking place towards the south and south-east to interrupt that continuity. Hence the sudden transition from a thick limestone to a thin one, and from that to these thick shales, which made it extremely puzzling to identify the beds, as he dared say both Mr. Lebour and Mr. Bewick were well aware. In these various beds, however, whether five, eight, or ten, there were certain fossil forms peculiar to each, and if these were carefully examined, they would be found occurring in certain beds, dying out, and from time to time re-appearing in other beds; and these formed much better tests for distinguishing the limestones than any purely lithological one. This was a very important fact, and he thought if Mr. Lebour or Mr. Bewick were to devote close attention to the recurrence of these special fossils in the various beds, there would be little difficulty in identifying them, even at thirty or forty miles distance. There was another point: he should have liked very much if Mr. Lebour had given some information respecting the argillaceous nature of these limestones. They were aware that Great Britain was now becoming a great cement-making country. Cement is made from chalk and clay, an artificial mixture, while it is very well known that in Scotland and Northumberland, there were many beds of argillaceous limestone which required only to be burnt in peculiar kilns and converted at once into hydraulic limestone. Within the last year, Stuart and Co., of Edinburgh, had tried seven different varieties of the argillaceous limestones of Scotland, and found them answer their purpose equally well with the artificial cement, and they are now making a selenitic mortar from the Scotch limestones, and not buying a single ounce of Portland cement for their manufacture. It would be worth while, economically, to direct attention to the argillaceous nature of these limestones—for many were highly argillaceous—to see how far they would be found to be adapted for hydraulic cement instead of falling back on artificial mixtures such as is the practice on the banks of the Tyne.

Mr. LEBOUR said, with regard to the power of these limestones to be used for cement, he might say that some of the upper limestones had been

To illustrate Mr. Lebow's paper on "The Little Limestone and its accompanying Coal in South Northumberland."



Diagram showing the chief divisions occurring in the Upper or "Acumb" Coal Group of Beds from the Alston to the Belsay District, the Fell-top Limestone being taken as a datum-level.

A. Fell-top Limestone. B. C. D. Interpolated Limestone. E. "Great" Limestone. F. Main Coal.



Sketch-Section of country from Middleton to Belsay



Sketch-Section from Hillhead to the Tyne

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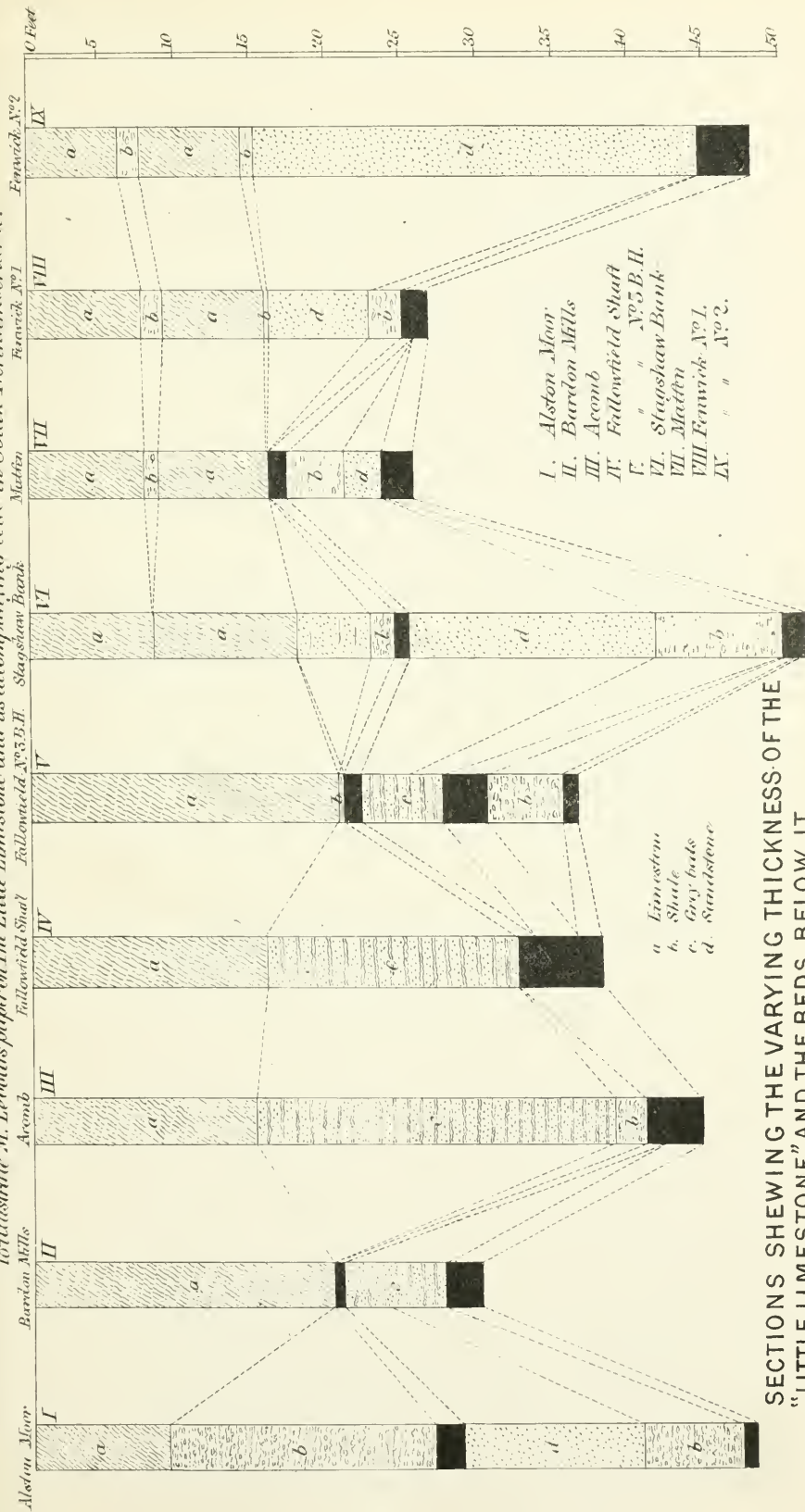
N.B. The Lettering is the same in the three figures.

Scales

Horizontal in Fig. I $\frac{1}{2}$ mile $\frac{1}{4}$ $\frac{1}{8}$ $\frac{1}{16}$ $\frac{1}{32}$
 " " in Figs. II and III $\frac{1}{2}$ mile $\frac{1}{4}$ $\frac{1}{8}$ $\frac{1}{16}$ $\frac{1}{32}$
 Vertical in Figs. I, II and III $\frac{1}{2}$ mile $\frac{1}{4}$ $\frac{1}{8}$ $\frac{1}{16}$ $\frac{1}{32}$

The Beds below the "Great Limestone" are not shown.

Illustrated M. Lechaup's paper "The Little Limestone and its accompanying Coal in South Northumberland."



SECTIONS SHEWING THE VARYING THICKNESS OF THE "LITTLE LIMESTONE" AND THE BEDS BELOW IT.

tried ; he did not know whether this Little Limestone had been, but the Great Limestone had been tried and found wanting altogether without admixture. But when the lower series are reached many of the limestones are very well adapted for cement making, especially those of the Calciferous Sandstone or Tuedian series. There are, doubtless, a large number of these argillaceous limestones, which no doubt make very good cement, but the limestone which was the special subject of this paper had never, he thought, been tried in that respect, nor did he think its argillaceous character was sufficiently marked to make it yield good cement.

Mr. BEWICK might mention, that he believed Mr. Benson, of Fourstones, was at this moment erecting cement works with a view to utilize some part of the products which he had at that place, and which consisted of limestone, sandstone, and shale. What Mr. Benson's plans were, he did not know ; but he was erecting a very large manufactory at Fourstones, and he believed with this object. If even these limestones exist in a state in which they can be converted into cement, they would not be commercially valuable, unless near a railway.

The CHAIRMAN asked if any other member had any remark to make ? If not, he hoped they would pass a vote of thanks to Mr. Lebour for his paper, and then adjourn the discussion until the next meeting.

The vote of thanks was then put and carried unanimously.

Mr. T. J. BEWICK read the following paper on "A Project for supplying Newcastle-upon-Tyne and other Towns and Villages in Tyne-dale with Water from the Northumberland Lakes District."

A PROJECT FOR SUPPLYING NEWCASTLE-ON-TYNE, GATES-
HEAD, AND OTHER TOWNS AND VILLAGES IN TYNE-
DALE WITH WATER FROM THE NORTHUMBERLAND
LAKES DISTRICT.

BY T. J. BEWICK.

THE interest recently created and the consideration necessarily given to the question of an adequate supply of pure water to this and other towns in Tynedale may be deemed sufficient reasons for the introduction of such a matter to the members of this Institute.

It is admitted that to secure cleanliness, maintain health, and add to the wants and comforts of the people, especially when collected in large masses, an ample and constant supply of good wholesome water is absolutely necessary, and it is not denied that this and other towns, and the populous districts by which they are surrounded, are in need of additional sources of supply.

With these points, therefore, as well as regards the merits of other projects, existing or otherwise, having the same object in view, it is not the writer's intention to interfere, confining himself as much as possible to facts and simply describe the engineering circumstances of the project submitted for consideration, which is now pretty well known as the "Northumberland Lakes Scheme."

In the western part of this county, lying between the North and South Tyne rivers, and distant from Newcastle, in a direct line, about thirty miles, are the Northumberland Lakes, the three principal being Greenlee Lough, Broomlee Lough, and Crag Lough, Plate XVI. The remarkable configuration of the ground at each of these places renders it well adapted for the easy formation of storage reservoirs of large capacity, and at an elevation commanding the whole valley of the Tyne, as well as Carlisle and towns to the west.

The natural drainage area of the lakes is limited to about six-and-a-half square miles, but by a system of catchwaters no less than sixty square miles of gathering ground is available, and even this is capable of augmentation.

The gathering ground extends into Cumberland, and comprises the upper portions of the rivers Irthing and Toppald on the west, and Warks Burn-head on the east, Plate XVII.

This area is exclusively in the geological formation, known as the carboniferous or mountain limestone, which here consists of a series of beds, alternating with more or less regularity of order, of sandstone shale and limestone, with an occasional thin seam of coal, which, with one or two exceptions, are unworkable, and even when so, to an extremely limited extent. The prevailing rocks are sandstone and grits, which are estimated to comprise sixty-six per cent. of the whole surface strata, while the shales may be taken at twenty-eight per cent., the limestone forming a small proportion, not exceeding six per cent.

A considerable proportion of the area has a surface covering of peat, but there is a total absence of towns, villages, hamlets, manufactories, and mines, other than the coal workings before referred to, and which, except that it is desirable to put all the facts before you, are scarce worthy of mention.

There are within this gathering ground only thirty-two places of habitation, and the entire population thereon cannot exceed 200, being $3\frac{1}{3}$ rd persons to each square mile.

One of the most important elements of consideration, in selecting a drainage area, is its rain-fall. In this case there are not, according to the published records known to me, any gauges, and we are therefore driven to draw comparisons.

Rain-fall, upon which all calculations in such cases are based, is more or less influenced by elevation, and taking the nearest stations of which records are published, and altitudes ranging between 600 and 2,000 feet, which is 160 feet below the lowest (760 feet), and 300 feet above the highest (1,700 feet) point within the limits of the proposed gathering ground, we have the following, viz. :—

Name of Station.	Altitude above Sea.	Rain Fall, as per Mr. Symons' Returns.					Average. Inches.
		1869. Inches.	1870. Inches.	1871. Inches.	1872. Inches.	1873. Inches.	
Wolfelee	604	40·57	33·50	37·30	57·04	39·29	41·54
Kielder	673	...	...	43·67	64·67	45·74	51·36
Gunnerton Burn ...	676	29·90	...	29·24	44·57	25·25	32·24
Byrness	700	34·35	28·12	...	54·21	...	38·89
Kirkton	759	29·60	25·30	31·00	52·80	35·60	34·86
Saughtree	760	...	...	39·76	60·18	42·03	47·32
Green Crag	800	30·59	...	31·49	45·82	27·13	33·76
Dean Head, No. 1 ...	800	...	...	...	50·06	...	50·06
Dean Head, No. 2 ...	800	...	...	...	49·87	...	49·87
Borthwickbrae	800	44·10	29·40	37·80	60·00	40·90	42·44
Whitfield	806	45·84	...	...	...	...	45·84
Riccarton	853	...	...	...	63·38	48·17	55·77
Allenheads... ..	1,353	54·44	44·27	...	65·86	36·64	50·30
Deadwater... ..	2,000	50·30	37·50	42·80	82·70	63·00	55·26
Mean	885	39·96	33·01	36·63	57·78	40·37	43·60

Thus an annual average gross rain-fall of 43·6 inches is arrived at ; but taking the year in which was the least, namely, 1870, 33 inches might be considered as a minimum at an average elevation (including only the six stations recorded that year) of 1,036 feet, which, it may be assumed, is the mean height of the gathering ground.

Making the usual deductions for what runs to waste during floods, and for compensation to mill-owners and others, and allowing for evaporation and absorption, the gross fall of rain is reduced to a nett available fall of nine inches, and this on a gathering ground of sixty square miles gives 7,841 million gallons per annum, or over twenty-one million gallons per day, a quantity far in excess of the requirements of the entire population of Tynedale.

These are the results derived from the gross drainage area of sixty square miles shown on the plan, but of this forty-two square miles are commanded by the formation of the catchwaters on the south-west side of the gathering ground, and, assuming this only to be utilized, the result is, according to the rain-fall of 1870, the driest of the last five years, a

total of 5,489 million gallons, or at the rate of fifteen million gallons daily, sufficient of itself for 450,000 people.

Although the usual reduction for compensation to mill-owners is allowed, in this case the number of mills and their importance are of such trifling moment that probably the question might be met by the purchase of the mills or the construction of compensation reservoirs, the cost in either case being comparatively unimportant.

According to the census of 1871 the population of Newcastle-upon-Tyne was 128,443, and of Gateshead 48,627; and if to these is added the other towns and districts extending from Hexham on the west to Tynemouth on the east on the north side of the river; and from Blaydon to Jarrow on the south, there are probably at the present time, allowing for increase of population, not less than 300,000 people requiring water, and that, in the year 1901, or twenty-seven years hence, when the first census of the twentieth century is taken, the population may be half-a-million.

For these numbers it is necessary to provide, or, at any rate, be prepared for the larger figures, and, taking the consumption at thirty gallons per head per day, the present requirements are nine million gallons, and by the commencement of the next century we may calculate on a consumption of fifteen million gallons daily.

Thus, allowing for 170 days continuous drought, it is necessary to provide storage for 1,530 million gallons to meet the present requirements of the population, and keep in view, as the necessities of our successors thirty years hence, storage for 2,550 million gallons.

The Northumberland Lakes, enlarged as now proposed, are ample for the purposes required, as is shown by the following figures, without taking into account their present capacity, with which it is not proposed to interfere :—

	Height proposed to be raised.	Elevation above Sea of Water when raised.	Estimated Area when raised.	Estimated Capacity when raised.
	Feet.	Feet.	Acres.	Million Gallons.
Greenlee Lough	30	761	464	3,000
Bromlee do.	25	855	186	1,000
Crag do.	20	800	68	350
Total ... ..	...	...	718	4,350

The figures in the last column are approximate only, but the margin is so large that they do not materially affect the question, and by raising

the embankments a few feet higher the capacity of each of the reservoirs may be augmented to keep pace with the increase of population probably for centuries to come.

The highest part of the district to be served may be taken as under 400 feet above sea level, hence there is not any difficulty in supplying water by gravity without the intervention of pumping machinery.

Greenlee Lough, as the most important of the three, is ample for present requirements, and this, it is suggested, may be utilized in the first instance, while, as need arises, Crag Lough and, eventually, Broomlee Lough could be made available, and this at the mere cost of embankments and connection with the canal or pipes, the elevation and position of the two latter not rendering necessary other works.

The altitude of the storage ground being so much above all the points of supply, renders it comparatively easy to deliver the water either into the existing reservoirs of the Newcastle and Gateshead Water Company, at Hallington, which is 500 feet, or at the Whittle Dene Works, which are 400 feet above sea level; or, on the other hand, it may be taken direct to an elevated point near Newcastle (say at Fenham), and there discharged into a service reservoir at an altitude commanding the highest houses in the towns proposed to be supplied.

By way of epitome it may be explained that the first works contemplated comprise :—

1.—Catchwaters on the south-west side of the gathering ground about fourteen miles in length.

2.—(a) An embankment across the valley west of Greenlee Lough for impounding, say, 3,000 million gallons of water therein. (b) A short embankment at the east end of Crag Lough, by which about 350 million gallons of water may be impounded at that place.

3.—A tunnel between Greenlee and Crag Loughs about one mile in length.

4.—A channel for conveying the water from the lastly-described work to Hallington, Whittle Dene, or Newcastle. To the first the length would be fifteen miles, to the second sixteen miles, and to the last thirty-and-a-half miles. This channel would be partly formed as an open or covered aqueduct, to save long circuits on the contour there would probably be two or three short tunnels, and the remainder would be cast iron piping. Of the latter the principal part would be in crossing North Tyne river, where about three miles of piping would be needed. With this exception the entire distance to the point of discharge into the Whittle Dene Works would be accomplished by a channel having a uniform fall of eight or

ten feet per mile. If the water was conveyed direct to Newcastle twelve miles of additional piping would be required from Matfen Piers to Fenham.

The cost of the works contemplated in this project it is impossible to estimate with any degree of exactness without correct plans, sections, and other data, which to prepare would necessarily occupy much time and incur considerable expense.

Approximately, however, it may be taken that, to store and deliver into the existing works an abundant supply of water to meet the requirements for some years to come, £150,000 would cover everything, but to continue the piping to Fenham, and thus secure a constant high pressure service, a further sum of £130,000 may be reckoned upon as necessary.

Not having an analysis of the water the quality is not attempted to be described. That it is peat-stained in floods is a fact, but inasmuch as it is derived from a gathering ground where the rocks are favourable, where mines and manufactories do not exist, and where, from the sparseness of population and the absence of cultivation, contamination from these causes is absent, it will bear comparison with almost any water, abundant in quantity, in the United Kingdom.

The CHAIRMAN said, they were very much obliged to Mr. Bewick for this important paper, and they would be glad to hear the remarks of any member present.

Mr. BEWICK, in answer to Professor Page, said that 33 inches was the lowest fall in the last five years gaugings, as was shown by the tabulated form, and that in his opinion there was no likelihood of any great drainage or improvement of the land there for agricultural purposes, or the cutting down of any woods which might exist, within, perhaps, the next forty or fifty years that would in any way lessen the rain-fall. He could not say exactly what was the nature of the surface he proposed to use as a gathering ground, because he had not walked over every point where he proposed to put catchwaters, but he knew the ground generally, and felt sure it would not have a tendency to pollute the water. If there was peat it would have to be cleared away till a sufficient foundation was reached, or the catchwater would be lined with masonry and, if necessary, cemented. There was very little cover upon the rock on the south side, and the peculiar formation was caused, as probably Dr. Page knew, by the presence of the whin sill which crops out along the line of the Roman Wall. All

the different strata there, and also on the north side, are at a high angle rising to the north, and form a series of ridges and depressions at right angles to the beds—in fact, a series of steps or stairs. The rock crops out at the surface on the south side, forming an escarpment more or less steep; but on the north side, and at the west end of Greenlee Lough, there is alluvial or peat land.

Professor PAGE said, this was a very important consideration. In several American water-works where they had extended the area of lakes, they had given rise to a new growth of aquatic vegetation, which had been the means of polluting water which was otherwise pure; and this was always to be taken into account in extending the area of any lakes. Then it was not only the growth of aquatic and marshy plants that had to be guarded against, but as these flourished, the growth of entomostraca and other minute animalcules increased, and those had a tendency very much to pollute any water supply. If the new ground over which Mr. Bewick proposed to extend these lakes be of this character, it would have a very injurious effect upon the ultimate quality of the water. In one instance, in America, so numerous did entomostraca become, that they had absolutely to empty the reservoir, and to excavate five or seven feet out of the bottom soil in order to get quit of the nidus, which gave rise to the aquatic growth, and animalculæ. It had been proposed by many civil engineers to put screens to screen off these living creatures, which were very minute, to prevent them passing through into the water pipes; but while living animalculæ could be screened off, there was no means of screening off the decayed animalculæ which gave rise to a peculiar fishy kind of oil. Then with regard to peat: he was strongly of opinion from having examined a good many water-works, that peaty water was not injurious to that extent which was generally supposed. They would observe that peaty water arose from dead and mineralized vegetation, the injurious effects of which had long since been discharged. It was only the solution from decaying vegetation they had to guard against, and not peat; so that he would not be deterred from this scheme even although the water had a peaty discolouration. The colouring matter was harmless, and could be got rid of by filtration.

Mr. BEWICK said, in reply to Professor Page, there was no doubt that in proposing to take this increased area it was of consequence to ascertain to the quantity of peat and vegetable matter within the limits to be covered by water. But he might say that it was the practice of water engineers to absolutely remove from the bed of the reservoir which they intended to be used for water for domestic purposes all vegetable and

other objectionable matter either on to the bank or to the outside of the lake altogether, so that the water might rest entirely upon the sand, clay, rock, or whatever might be there, and be perfectly free from vegetable or animal contamination. The observations of Dr. Page with reference to peaty water were, he believed, borne out by every chemist and engineer of the day. It was true that peaty water was objectionable to the eye; but he was advised by those who had gone fully into the matter that with this exception there was nothing deleterious about it. He believed that if they searched all the schemes which had been proposed, from Mr. Bateman's for supplying London from the Welsh Hills downwards, they would not find a single case in which more or less peat had not been ascertained to exist in the water which it was proposed to utilize; and the celebrated Loch Katrine works themselves, which were held up as a pattern, and he believed deservedly so, were supplied by peaty water. It was stated by Mr. Bateman and others, who were competent to form an opinion from their large experience in these matters, that by storing this water in the reservoir for a considerable length of time, or in the course of passing it through a long canal, a great deal of this discolouration might disappear either by settlement or by some chemical action; and that therefore this water, on being delivered at a town a long distance off, like Glasgow from Loch Katrine, which was about thirty miles distant, was not so objectionable even to the sight as when first collected in the reservoirs.

Prof. PAGE—To make an artificial foundation or artificial ground, would add very materially to the expense of increasing the area of these lakes?

Mr. BEWICK said, he did not propose to form an artificial foundation: he proposed to do what was always done. Reservoirs were formed on moorlands, amidst heather, peat, and plantations; but no engineer of position would allow any part of those reservoirs to be filled and utilized with water for domestic purposes with this vegetable matter upon it. What he did was to clear off and remove it outside of the reservoir altogether; and he would not call that making an artificial foundation, it was the natural foundation, the artificial matter having been removed.

Prof. PAGE said, there was another question: leading the water from these lakes into the Whittle Dene or Hallington reservoirs, would require several tunnels and embankments. The embankments would not pollute the water or interfere with its purity as it flowed from the lake; but if it had to pass through tunnels, and those tunnels were

not bricked or concreted, and so on, the passing water might be receiving supplies from calcareous or chalybeate, or sulphuretted springs, which might interfere very much with the purity of the water as it was ultimately discharged into the Whittle Dene and Hallington reservoirs. He did not know if this was a question which Mr. Bewick had looked at.

Mr. BEWICK said in this case, the only tunnel of any moment was from the Green Lee Lough ; and this would pass almost entirely through sandstones and shales. As he mentioned in his paper, there were two or three short tunnels to avoid long contours, but these were comparatively insignificant. From his experience in mining works, in tunnels and drifts, he did not think that any quantity of water could get into any tunnel proposed by him, or even a longer tunnel, that could preceptibly affect the large quantity of water which was being taken through such tunnel. Should they get any calcareous matter, it would be so minute as not to affect it. The strata was such that there would not be anything to contaminate the large body of water flowing through the tunnels.

Professor PAGE said he only made this observation, because in the great St. Mary's Loch scheme, at Edinburgh, they had to pass through several miles of soft schists, in which were the Moffat waters ; and if any large solution of sulphuretted hydrogen or copper were to be found in drinking water it would be very objectionable ; and the question was whether Mr. Bewick's scheme would pass through strata which might throw any mineral impurity into the water.

Mr. BEWICK—Not in this particular case. There is not any schist, and he was not aware of even a Gilsland spa in this neighbourhood ; neither did he think that there was anything that would affect it. But at any rate, taking again the example so often referred to, the Loch Katrine works, there they had a large number of tunnels, which he believed were partly driven through the schist and primitive rocks.

Professor PAGE—Chiefly through the trap-rocks.

Mr. BEWICK—But he was not aware that there was contamination, nor had he ever heard of any contamination arising from water conveyed to towns through tunnels. It might be, but he thought it would be so very small indeed, considering the large quantity of water that had to be passed through, that if even all the Moffat springs were put into the nine millions of gallons of water passing through this tunnel per day, it would he thought be so extremely small, as to be perfectly inappreciable at the end. He saw the force of Dr. Page's observation, and was obliged to him for mentioning it.

Mr. LEBOUR said, it might be worth while mentioning that some time ago, on hearing of this scheme for the first time, he went into the question of the rain-fall of the district; and from all the information he could then get—of course from quite independent sources—he came to the conclusion that about 35 inches would be about the average. But since that time there had been some bad years which would lower the average. This seemed to confirm what Mr. Bewick had said.

Mr. BEWICK said, as already explained, he had taken the driest of the last five years; and if he had taken, what was not uncommon with hydraulic engineers, the three driest consecutive years, it would have given considerably more than he put it, inasmuch as the driest three consecutive years would have been—in 1869, 39·96; in 1870, 33·01; and in 1871, 36·63. They would then have had something like 36 to 37 inches instead of 33; so that he did not think he had exaggerated the case. He would be very sorry to do so. He had endeavoured, if possible, to keep within rather than beyond the mark. If any gentleman had experience in the rain-fall of these hills, perhaps he would enlighten the members and state what his views were. He believed he was quite within the mark. He thought the actual realization would be, even in the very driest years, an excess of what he had stated.

The CHAIRMAN thought that until the paper was published they should adjourn the discussion, and, probably, by that time he would have something to say about it.

Mr. J. M. REDMAYNE would like to make one remark. The Chairman, being a member of the Tyneside Naturalists Field Club, would be aware that, when they went in search of animalculæ, they were recommended first and foremost to go to these loughs; and this had always been a stumbling block with him in this water question, and he was afraid that even although a large quantity of this soil and the vegetation about it might be removed, still the water must deserve the same reputation it enjoys at present.

The CHAIRMAN would make one more remark. He was sorry he could not concur in the remarks as to the wholesomeness of peat water. They were always cautioned by the gamekeepers when they went shooting to beware of peaty water, and he knew that it was not very wholesome. He could not conceive that any drainage from peat soil could be made wholesome by allowing it to stand in a reservoir for any length of time. The thick part of the contamination might be separated, but that which was dissolved would remain. Any other remarks he would reserve till

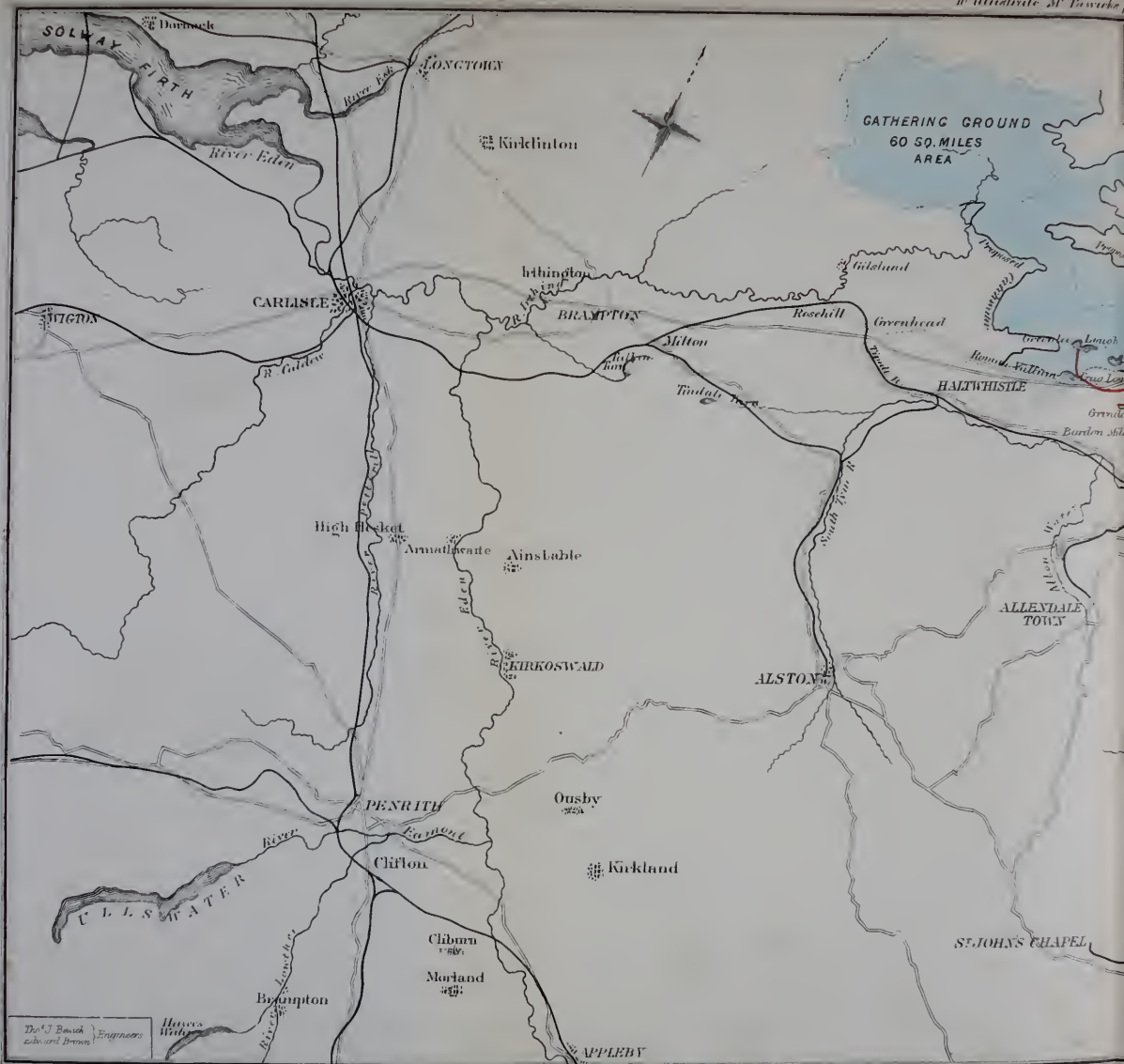


trate 2



Greenlee





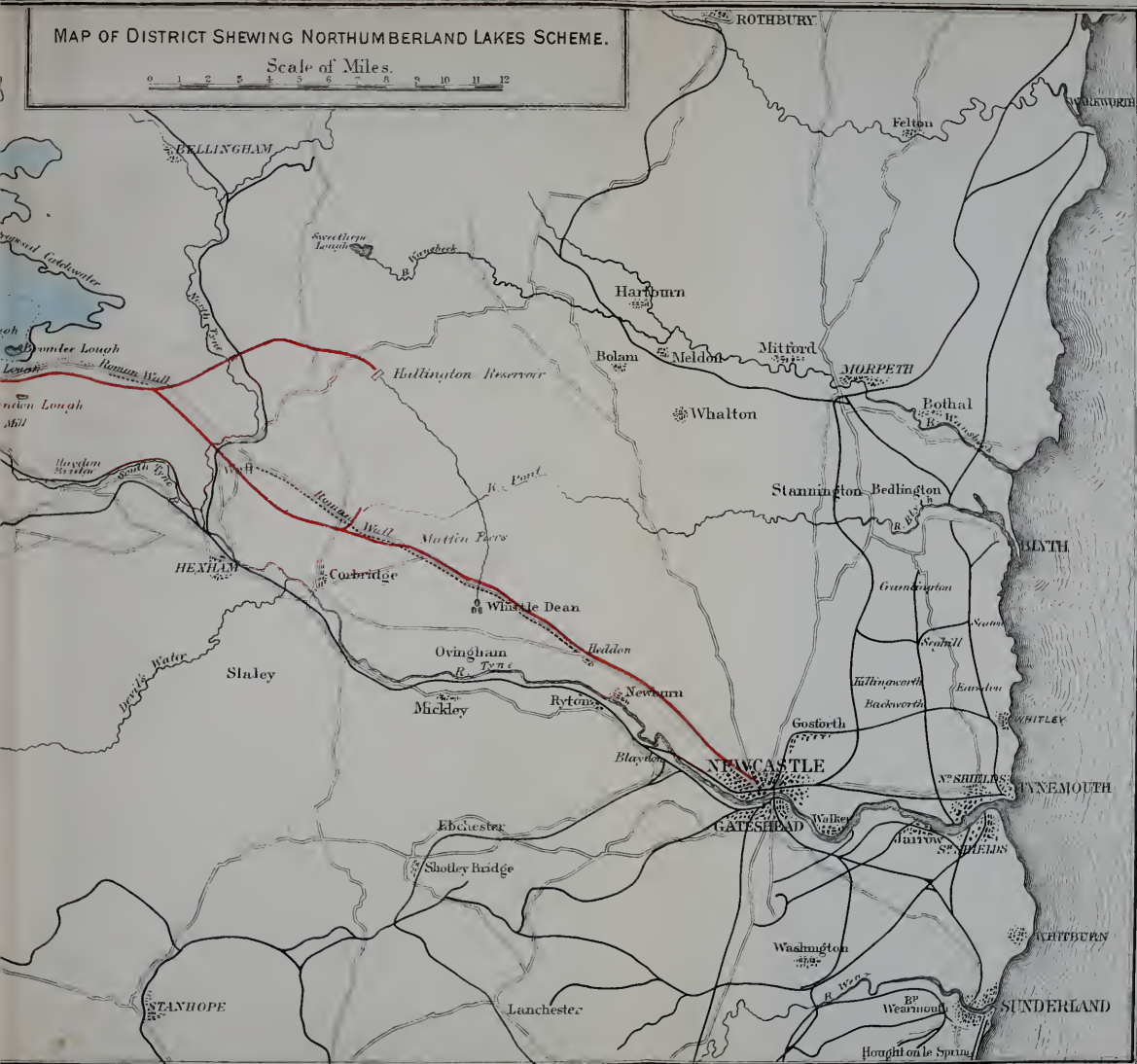
Do J. Busch
and Son

Harvey
Wright

MAP OF DISTRICT SHEWING NORTHUMBERLAND LAKES SCHEME.

Scale of Miles.

0 1 2 3 4 5 6 7 8 9 10 11 12



the next meeting. He simply had now to propose a vote of thanks to Mr. Bewick for his paper.

The motion was carried unanimously.

The following paper by Mr. Henry Aitken, on the "Description of Coking Ovens, as erected at Almond Iron Works, near Falkirk, N.B.," was considered as read and ordered to be printed.

The meeting then concluded.

DESCRIPTION OF COKING OVENS AS ERECTED AT ALMOND
IRON WORKS, NEAR FALKIRK, N.B.

BY HENRY AITKEN.

THE object of this paper is to describe these ovens and the results obtained from them, and not to treat of coking generally. Nor will they be compared with other ovens, except in so far as may be unavoidable. The ovens will be described and the results given, while those interested will be left very much to draw comparisons for themselves.

The drawings show three ovens of the new type, the novelty of which consists in forcing either heated or cold air into the space above the upper surface of the materials being coked so as to turn the gases and promote the coking process.

Plate No. I. is the ordinary Beehive oven with the blast applied. A cross section of the oven is shown on Plate XVIII. A is the chamber of the oven, B the outlet for the gases, C the pipe round the top of the oven containing the blast from the fan or other forcer, D D are the small air-holes for admitting the air into the oven, and E is the doorway by which the coke is drawn out. Fig. 2 shows to the right, a section of the air passages D connecting with the pipe C, and to the left, a plan of the top of the oven. The working of this oven is as follows :—

When the oven has been properly dried and heated, it is charged either through the doorway E, or the outlet B, and so soon as the heat has evolved and ignited sufficient gas, the blast is turned on and the air forced in through the apertures D, and the blast is continued and regulated so long as gas comes from the coal, the outlet B being partially closed, and the air being regulated, so that the mixture of gas and air, till near the end of the charge, shall always have in it some unconsumed carbon. The quantity of air required is always largest at the beginning of the charge, and gradually diminishes to the close. So soon as the gas is all evolved, the coke is either allowed to cool down, or is watered out, and drawn.

Plate XIX. shows the novelty applied to horizontal through-and-

through ovens, to enable the material to be drawn out with the engines or cranes. Fig. 1 shows on the right a part longitudinal section. The letters A, B, C, D, and E represent the same parts as in Plate XVIII. Fig. 2 shows a cross section of the same. Fig. 3 shows on the right a section of the top of the oven at the air inlets, and on the left a plan of the same.

The following are the results obtained in working the oven No. 1 (Beehive) for about twelve months with the different coals specified :—

	Average yield by Retort, breezes included.	Average yield of Oven, free from breezes.	Loss.
Blackbraes Semi-Caking Coal, free from breezes, 17 charges con- secutively }	66.45 %	65.27 %	1.18 %
Weardale Iron Co.'s Hedley Hill or Medburn Coal, 14 charges con- secutively }	73.94 „	69.46 „	4.48 „
Messrs. Newton & Chambers' Thorn- cliffe Coal, Staffordshire (Silkstone seam), 4 charges consecutively ... }	65.63 „	62.65 „	2.98 „
Watson's Binniehill (Scotch), splint ground, 1 charge }	66.52 „	65.18 „	1.34 „
Do. Soft or Coxroad Seam, ground, 2 charges consecutively }	68.75 „	65.19 „	3.56 „

The average charge put into the oven was 3 tons 4 cwts. of coal, and the average time from charge to discharge 62 hours. With the same coal in ordinary Beehive ovens, the time required is 80 hours. The time varied, however, according to the nature of the different coals. The quality of the coke produced is pronounced by all the parties who have seen it to be first-class—equal to any made from the ordinary Beehive oven. The weighing was done with the greatest care, and, with the exception of Blackbraes, the weights were checked by representatives of the parties whose coal was being coked, and may be depended upon as correct. The losses with Medburn coal and Binniehill soft are exceptionally high, owing to the large amount of dirt in them, causing a great quantity of breezes.

The results from the oven No. 2 cannot be given in such detail as those from No. 1, as the oven has only been for a few weeks in operation ; but the yields are equally good, and the amount of breezes less. The charge is about the same, and the time taken rather less. The quality is even superior. At present the oven is drawn by crane in the old-fashioned way, but it is purposed to take it out with a large shovel, with or without sides, worked by a steam engine or hydraulic machinery (Plate XX.)

To illustrate Mr. Atkens paper on "Coking Ovens."

FIG. 1.

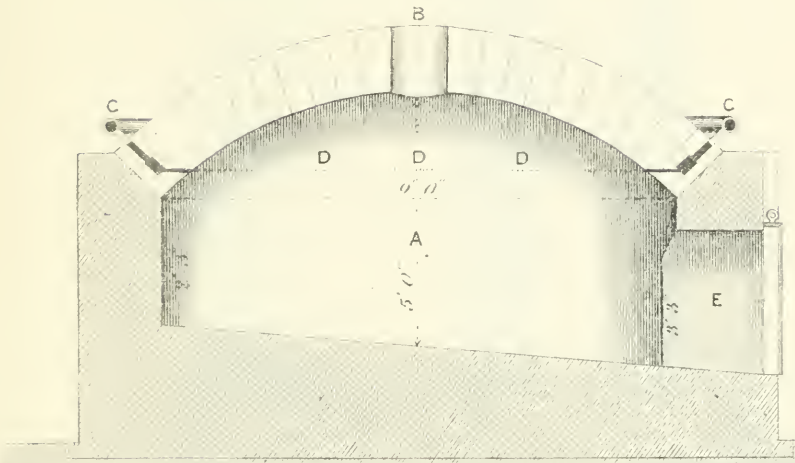
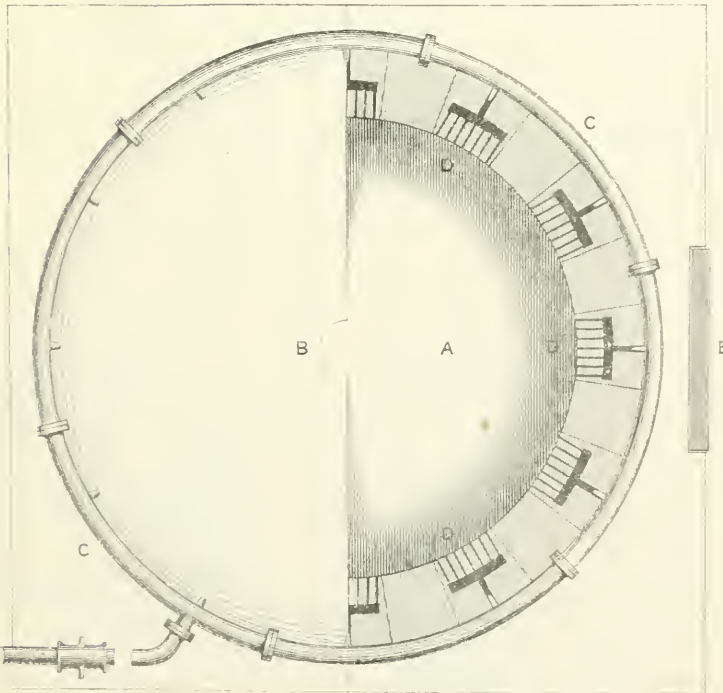
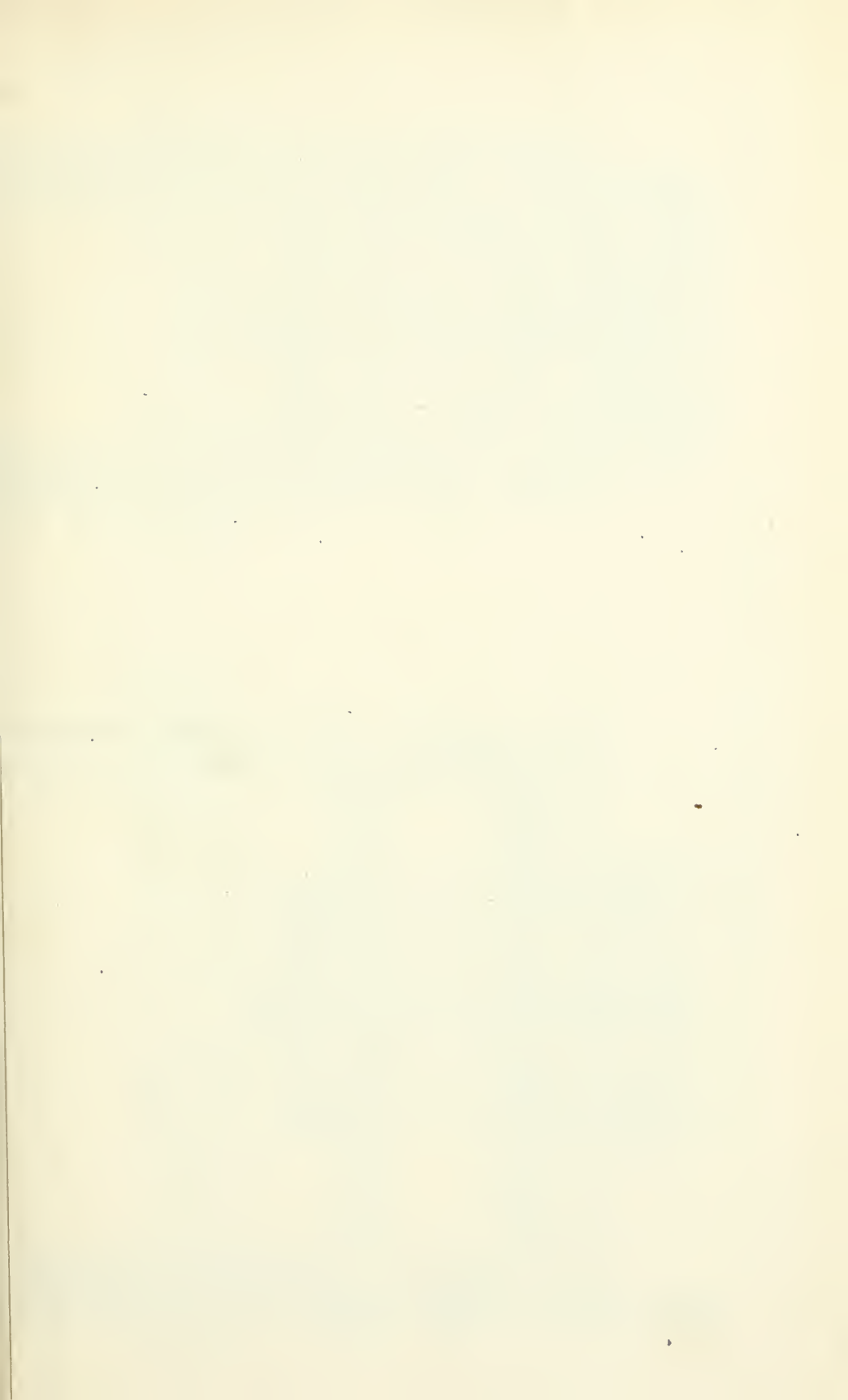


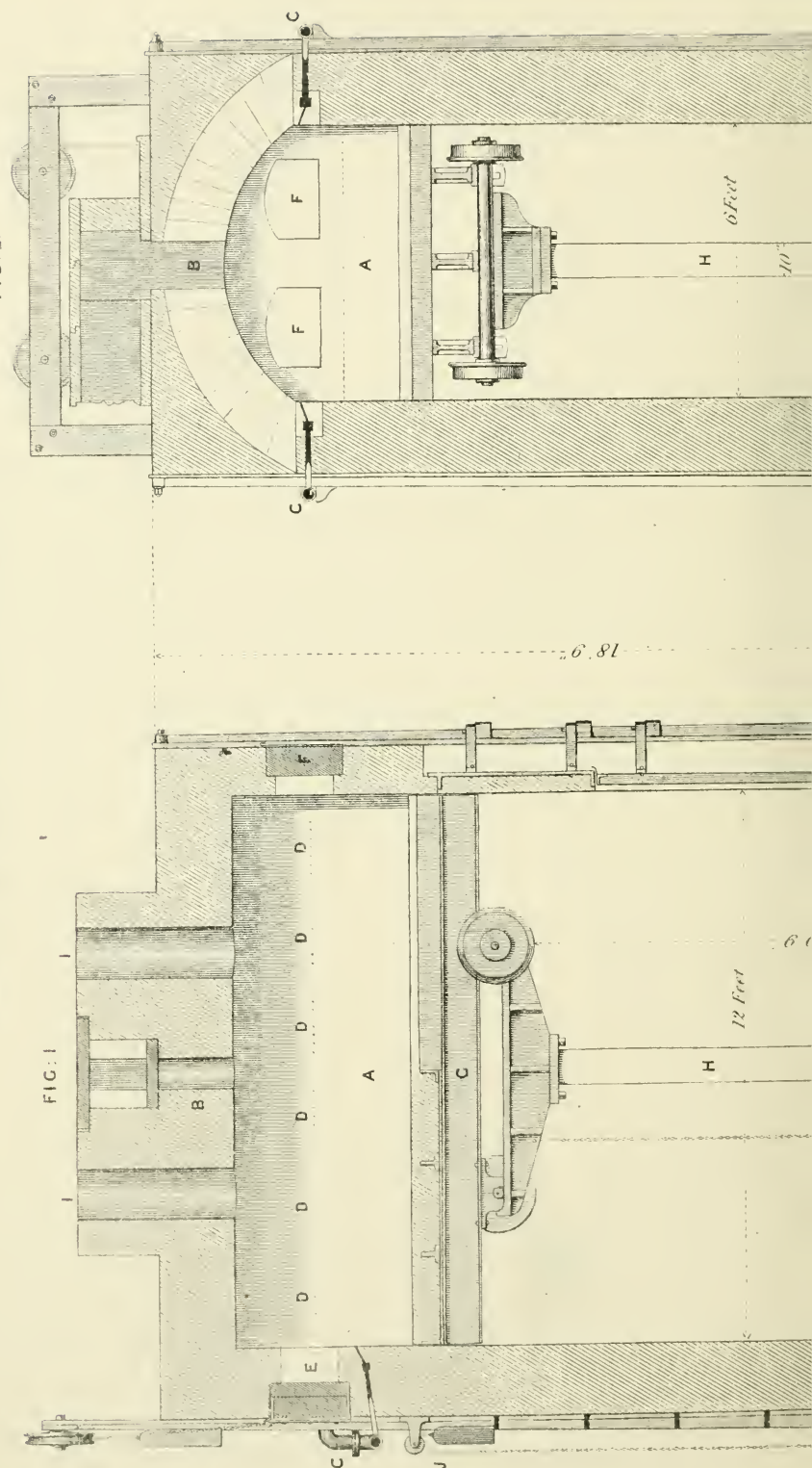
FIG. 2.

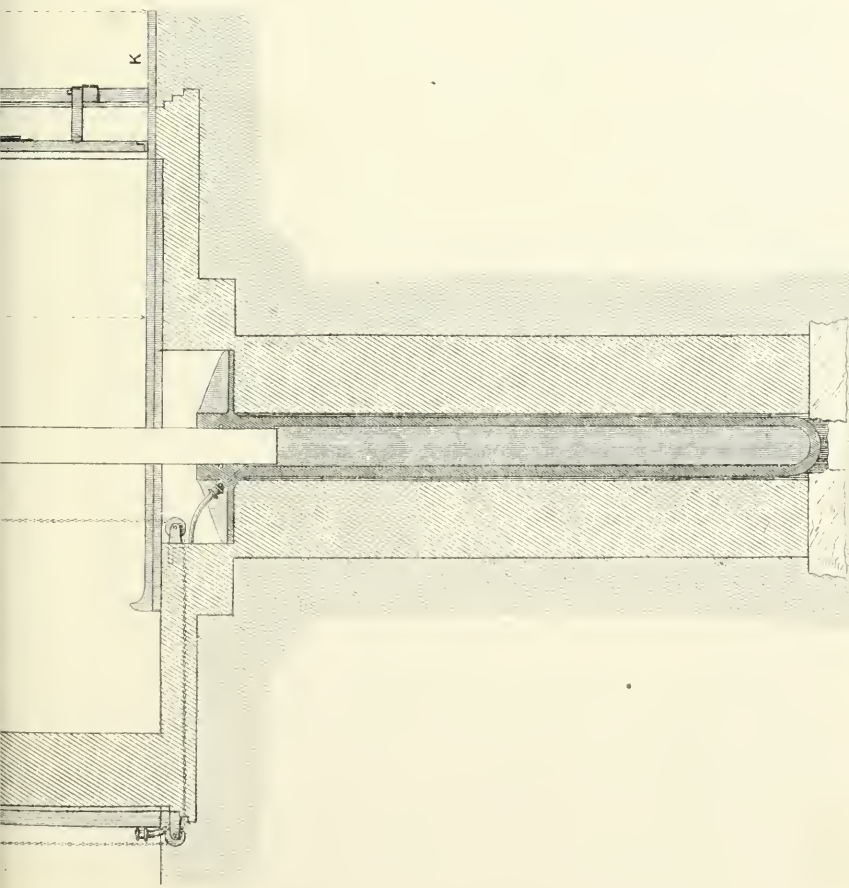
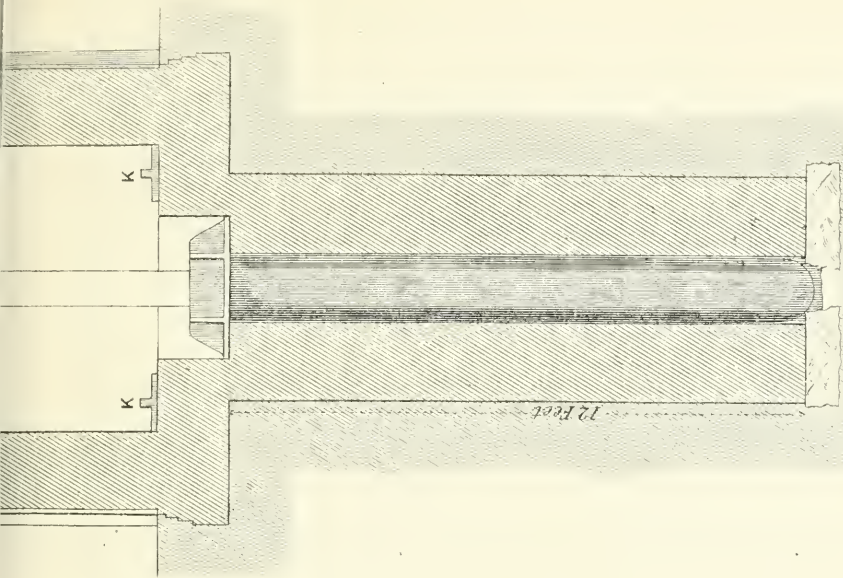




To illustrate Mr. Atkins's paper on "Coking Ovens."

FIG. 2.





As the coal in coking shrinks about an inch from each side of the oven, it is thought no difficulty will arise in working in this way. The coal is also to be charged by machinery.

It will be seen from the novelty adopted in these ovens that the temperature maintained is very high, and that the gases as they leave the oven not being charged with a great quantity of air can be utilized either for heating the air or for driving the fans for the blast. Even after this is done there should be a large surplus of available heat. With most coals, particularly those of a dull, semi-coking or partly-burnt nature, hot blast is to be preferred, but with a quick coal, cold blast does equally well. Although the ovens are subjected to a high heat, it is not found that the brickwork suffers. There being almost no waste of coke, and therefore almost no ashes formed, there is no fluxing of the brickwork with the iron, lime, &c., of the ashes as in ordinary ovens. Few coals have more tar in them than is required to make good coke, but where such a coal is made into coke these tars may be drawn off by a pipe or pipes at the bottom of the oven, the gas exit being partially closed, and thereby creating pressure sufficient to force the gases through the pipes. Several pailfulls of tar and ammoniacal water have, in some cases, been taken from a single oven, but the quality of the coke has always suffered.

Owing to the high heat got in these ovens, coal that could never be coked before has been converted into good coke. The Pleun Coal Company, near Stirling, has four ovens of their No. 2 coal tried, from which they never had been able to make coke, and the result was 66 per cent. of very fine coke. With these ovens the coke may be watered out as in an ordinary Beehive oven, and in this respect are unlike all descriptions of flued ovens where the gases are burnt in chambers separate from the coal.

The only extra expense that would be incurred in adopting this novelty is the cost of the pipes, fan, and engine. It is thought that one man could attend to the fans and engine and the regulation of air to 100 ovens.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, FEBRUARY 6TH, 1875, IN THE
WOOD MEMORIAL HALL.

J. T. RAMSAY, Esq., IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council.

The following gentlemen were then elected :—

MEMBERS—

Mr. JOSEPH THOMPSON, M.E., Manvers Main Colliery, Rotherham.
Mr. PETER W. PICKUP, M.E., Dunkenhalgh Collieries, Accrington, Lancashire.
Mr. JOHN GREENER, Albion Mines, Nova Scotia.
Mr. REGINALD WIGRAM, Steam Plough Works, Leeds.
Mr. JOHN H. COX, 10, St. George's Square, Sunderland.
Mr. GEORGE CHARLTON, Washington Colliery, Co. Durham.
Mr. GEORGE FRANKS, M.E., Victoria Garesfield, near Blaydon-on-Tyne.

STUDENTS—

Mr. ARTHUR C. MANN, Seaham Colliery, Seaham Harbour.
Mr. EDWARD AUBONE POTTER, Cramlington House, Northumberland.

The following were nominated for election at the next meeting :—

MEMBERS—

Mr. GEORGE HALL, South Garesfield Colliery, Lintz Green.
Mr. WILLIAM PAGE, 10, Grove Street, Newcastle-on-Tyne.
Mr. WILLIAM FOGGIN, Pensher Colliery, Fence Houses.
Mr. H. G. BOLAM, Little Ingestre, Stafford.
Mr. EMILE DELGOBE, Royal Greck Iron Works, Wallsend.

STUDENTS—

Mr. J. M. LIDDELL, Nedderton, Northumberland.

Mr. ROBERT MUNDLE, Redesdale Mines, Bellingham.

Mr. HENRY AYTON, Seaton Delaval Colliery, Dudley, Northumberland.

Mr. ROBERT E. ORNSBY, Seaton Delaval Colliery, Dudley, Northumberland.

Mr. FRANCIS A. POCOČK, Silksworth Colliery, Sunderland.

No papers were read.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, MARCH 6TH. 1875, IN THE
WOOD MEMORIAL HALL.

E. F. BOYD, ESQ., PAST-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the previous meeting, and reported the proceedings of the Council.

The following gentlemen were elected.

MEMBERS—

Mr. GEORGE HALL, South Garesfield Colliery, Lintz Green.
Mr. WILLIAM PAGE, 10, Grove Street, Newcastle-on-Tyne.
Mr. WILLIAM FOGGIN, Pensher Colliery, Fence Houses.
Mr. H. G. BOLAM, Little Ingestre, Stafford.
Mr. EMILE DELGOBE, Royal Greek Iron Works, Wallsend.

STUDENTS—

Mr. J. M. LIDDELL, Nedderton, Northumberland.
Mr. ROBERT MUNDLE, Redesdale Mines, Bellingham.
Mr. HENRY AYTON, Seaton Delaval Colliery, Dudley, Northumberland.
Mr. R. E. ORNSBY, Seaton Delaval Colliery, Dudley, Northumberland.
Mr. FRANCIS A. POCKOCK, Silksworth Colliery, Sunderland.

The following were nominated for election at the next meeting :—

MEMBERS—

Mr. J. J. REYNOLDS, M.E., Leigh Road, Atherton, near Manchester.
Mr. GEORGE SOUTHERN, 17, Wentworth Place, Newcastle-on-Tyne.
Mr. MATTHEW RICHARDSON, Jun., West Stanley Colliery, Chester-le-Street.
Mr. JOHN SIMPSON, West Stanley Colliery, Chester-le-Street.

The SECRETARY then read the following paper, entitled “The Present Form of Marine Engine used in the Commercial Navy of Great Britain.”

THE PRESENT FORM OF MARINE ENGINE USED IN THE COMMERCIAL NAVY OF GREAT BRITAIN.

BY THEO. WOOD BUNNING.

It was not until the successful adaptation of the screw by Smith, about the year 1842, that steam could be fairly said to be in use in the Mercantile Marine of this country. Paddle steamers, it is true, were used for transporting passengers and cargoes for limited distances with considerable success, but the screw soon showed its superiority over paddle-wheels for ocean navigation, and a new era commenced. Steam ships, moderately but effectively rigged, which could sail, as well as steam, and keep the sea in heavy weather, began to be employed in taking cargoes long distances; and now screw steamers are fast becoming the recognised carriers of the ocean.

Paddle-wheel steamers, however, will always continue in use where extraordinary speeds are required, or where the water to be navigated is too shallow for the proper immersion of a propeller suitable to the size and speed of the ship.

But for all the practical purposes of navigation, the screw has now proved itself so superior to the paddle, and is so much more universally applied, that the writer will confine his observations entirely to the present class of engine used in screw steamers.

With the information now available, it seems strange that at first it was judged necessary to employ spur gear to obtain the requisite number of revolutions of screw, and the first forms of screw engines were either oscillating or some other type that was then in use for paddle-wheel engines.

The spur gearing employed was, of course, very ponderous. For 120 horse power nominal, made by Messrs. John Penn and Son, of Greenwich, in 1845, for the Queen's yacht, the spur wheel on the engine shaft was 9 feet 6 inches diameter, and the pinion about 1 foot 11 inches; the spur was geared with hornbeam, its total width on the face was 20 inches, and there were three sets of teeth 6 inches wide placed side by side, each set

being placed in advance of the other by one third the amount of the pitch, which was 3 inches. This arrangement was to prevent back lash as much as possible. The pinion was of cast iron in three pieces, each piece keyed on the propeller shaft, so that the teeth were in advance of each other to suit those of the spur wheel.

It was soon seen that the screw ship was very superior to the paddle-wheel steamer as a fighting vessel, especially as it was found practicable to arrange the machinery horizontally, with no portion of either the engines or boiler standing above the water line ; to a certain extent the horizontal engine got introduced into the merchant navy at the same time.

The disadvantages attendant upon this form of engine, notably the extra friction and wear caused by the weight of the pistons and rods upon the lower surface of the cylinders, speedily caused it to be abandoned, except in cases where it was absolutely necessary that the whole of the machinery should be below the water line, and the upright form of engine became finally that which was most usually employed.

Steam had not long been used as a motive power when the advantage of expansion became apparent, and efforts were made in several directions to extend the benefits to be derived from expansion to marine engines almost as soon as the first solution of the problem of navigation by sea was made.

The following table shows the theoretical gain to be obtained by expansion, premising that no loss of power takes place during the stroke from condensation. This, however, in practice, is rarely the case, and a considerable reduction of the theoretical results must be made in consequence.

Table No. 1 is calculated from the formula that the hyperbolic log. of the number of expansions, plus 1, expresses the work done at each grade, the work done when not expanding at all being 1.

TABLE No. I.

THEORETICAL SAVING EFFECTED BY THE EXPANSION OF STEAM.

Times the original bulk of Steam is expanded.		Pressure above zero at end of Stroke.		Lowest pressure above zero required at commencement of Stroke.		Effect of 1 unit of Coal.		Per Cent. Saving over No. 1.		No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	No. 13.	No. 14.	No. 15.	No. 20.	No. 30.	No. 40.	No. 50.
A	B	C	D	Per Cent. Saving over No. 1.		Do.		Do.		Do.		Do.		Do.		Do.		Do.		Do.		Do.		Do.		Do.	
1	8	8	1																								
2	8	16	1.69	40.8																							
3	8	24	2.09	52.2	19.2																						
4	8	32	2.38	58.	29.	12.2																					
5	8	40	2.60	61.5	35.	19.4	8.5																				
6	8	48	2.79	64.2	39.4	25.1	14.8	6.9																			
7	8	56	2.94	66.0	42.5	29.	19.1	11.6	5.1																		
8	8	64	3.07	67.5	45.	32.	22.5	15.3	9.2	4.3																	
9	8	72	3.19	68.6	47.	34.5	25.5	18.5	12.6	7.9	3.8																
10	8	80	3.30	69.7	48.8	36.7	27.9	21.2	15.4	10.9	7.	3.4															
11	8	88	3.39	70.5	50.2	38.4	29.8	23.3	17.7	13.3	9.5	5.9	2.7														
12	8	96	3.48	71.2	51.5	40.	31.6	25.3	19.8	15.6	11.8	8.4	5.2	2.6													
13	8	104	3.56	71.9	52.5	41.3	33.1	27.	21.6	17.5	13.8	10.4	7.3	4.8	2.3												
14	8	112	3.63	72.4	53.5	42.5	34.5	28.4	23.2	19.	15.4	12.2	9.1	6.6	4.2	2.											
15	8	120	3.70	73.0	54.3	43.5	35.7	29.8	24.6	20.5	17.	13.8	10.8	8.4	6.	3.8	1.9										
20	8	160	4.0	75.	57.7	47.8	40.5	35.	30.3	26.5	23.3	20.3	17.5	15.3	13.	11.	9.2	7.5									
30	8	240	4.40	77.3	61.6	52.5	45.9	40.9	36.6	33.2	30.2	27.5	25.	23.	20.9	19.1	17.5	15.9	9.1								
40	8	320	4.68	78.7	63.9	55.4	49.2	44.5	40.4	37.2	34.4	31.9	29.5	27.6	25.7	24.	22.5	20.9	14.5	6.							
50	8	400	4.91	79.6	65.6	57.5	51.6	47.1	43.2	40.2	37.5	35.1	32.8	31.	29.2	27.5	26.1	24.7	18.6	10.4	4.7						
100	8	800	5.6	82.2	70.	62.7	57.5	53.6	50.2	47.5	45.2	43.1	41.1	39.5	37.9	36.4	35.2	34.	28.6	21.4	16.4	12.3					

Column D is the hyperbolic logarithm of the number of times the Steam is expanded to, plus 1.

From this it will be seen that, by expanding steam ten times in a low pressure engine, a saving of 69.7 per cent. is effected.

This in a well-constructed marine engine with suitable boiler can be explained as follows:—

The ultimate calorific value of 1 lb. of good steam coal is 14 lbs. of water, ten of which can be realized in a good boiler of the type now put on board ship.

10 lbs. of water = 277 cubic inches.

$277 \times 2,427$, volume of steam to water at 10 lbs. pressure above zero = 672,279 cubic inches of steam at 10 lbs. pressure above zero in 10 lbs. of water.

Equal 1 square inch \times 672,279 inches, or 56,023 feet; or 1 square

inch \times 10 lbs. pressure \times 56,023 feet = 56,023 foot pounds, for a consumption of 1 lb. of coal.

$$\text{Or } \frac{560,230}{33,000} = 17 \text{ horse power,}$$

produced for a minute by 1 lb. of coal :

$$\text{Or } \frac{1 \text{ lb.} \times 60 \text{ minutes}}{17} = 3.5 \text{ lbs. of coal}$$

per indicated horse power per hour, and this may be taken as the ultimate theoretical value of coal in a low pressure engine when using no expansion.

In practice, in well-constructed engines and boilers, this has to be multiplied by 1.7.

Or $3.5 \times 1.7 = 5.95$ lbs. or nearly 6 lbs. of coal, &c., required for each horse power indicated by the cylinder when the engine is exerting its maximum force.

Now, an expansion of ten times gives by the table 3.3 times the work done by the same steam not used expansively, which is equivalent to a saving of nearly 70 per cent.

$$6 \text{ lbs.} \times 70 = 4.2 \text{ lbs. saved,}$$

$$\text{Or } 6 - 4.2 = 1.8 \text{ lbs. used;}$$

and this may be taken as a fair expenditure per indicated horse power per hour for ten expansions in a good ordinary expansive engine.

Seeing the very large saving to be effected by expansion, it is not to be wondered at that efforts were made from the very first to extend the principle to steamers.

There were two causes, however, which, more than any others, prevented the adoption of high rates of expansion to marine engines. One was the difficulty in finding a suitable valve gear, and the other was that the earthy particles in salt water, notably the sulphate of lime, are deposited at a temperature of 300 degrees Fahrenheit, which corresponds only to a pressure of 66lbs. above zero, which would prevent steam of more than 55 lbs. above zero being employed, as of course a good margin would have to be allowed between the working and the depositing temperatures.

In spite of all the talent and ingenuity that has been displayed in scheming valves and gear, the slide valve has never been equalled as a simple, safe, and effective mode of distributing the steam, and, coupled with the double eccentric and link motion, may be unhesitatingly stated to be the only safe mode of working steam engines that have to go at high speeds under all difficulties.

Of course all the advantages that could be derived from the ordinary valve and link motion, combined with a moderate pressure, were speedily obtained by the well-known expedient of lap ; but no greater economy was ever permanently attained which exceeded the amount due to an expansion of the quantity of steam admitted to $1\frac{1}{2}$ times its bulk. This gives an economy of 1·4, and reduced the 6 lbs. by something approaching 30 per cent., or to about 4·2 lbs. per horse per hour, which for many years was the average consumption of fuel per indicated horse power per hour for first-class ocean steamers.

Irrespective of the difficulty of making any arrangement of slide valve of suitable simplicity to work at a higher rate of expansion than that indicated above, the great difference there would be upon the pressure on the pistons between the commencement and end of the stroke was also a difficulty, which seemed to point to the necessity of multiplying the number of engines to obtain anything approaching an equable torsional strain upon the screw or paddle-wheel shaft.

There was also another very serious difficulty in the way of improvement in the marine steam engine. Marine engines are expensive to construct, and if they are of any size their value is very great. When once, therefore, any given form of engine had been proved to be fairly successful, it was continued in and copied by all around. Besides, large firms had their expensive patterns, which they were unwilling to alter ; and small firms were frightened to make any but those classes of engines that had already proved successful. If any person not a manufacturer proposed a new and economical form of engine, he was not listened to by the large houses, even if he came with an order in his hand ; but was told that as in case of success the honour would be his, so in case of failure the loss would come on the builder, and if he persevered he was obliged to have his order executed by some indifferent firm who could not do him justice ; and so it came that marine engines were made for years of precisely the same type, with a little more or less Gothic architecture in the side frames., according to the taste of the builder.

Some thirty years ago it did seem, however, that one of the chief difficulties in the way of using high-pressure steam would have been conquered by the invention and introduction of Hall's surface condensers. These were a success from the very first, good vacuums were obtained, and they seemed at the time to be likely to come into universal use ; but they were expensive, and there was a supposed difficulty in keeping them clean. Besides, the saving they effected, unless used with high-pressure steam of some 75 lbs. to the inch, could never exceed that due to the

stoppage of the waste caused by blowing off, which really never was more than from 10 to 15 per cent. From all these reasons, and from the fact that they set up a chemical action in the boilers which was more or less injurious to them, they were consigned to the limbo of oblivion for twenty years or more, till about the year 1860, when they again occupied the attention of the engine builder.

It must not, however, be forgotten that intelligent efforts were continuously being made during this period to introduce high-pressure steam and surface condensation, and amongst the most successful of these efforts may be reckoned those of Mr. Rowan, in 1858.

Several engines on the compound principle were constructed by Messrs. Robert Stephenson and Co., of this town, to the designs of this gentleman, and they were eminently successful. An economy of fuel, unsurpassed at present, was the result; and had it not been for some unfortunate complication in the style of boilers adopted, there is no doubt the success would have been so great as to have ensured the universal adoption of the principle.

In reviewing this portion of the history of the compound marine engine, it seems strange that down to, say 1863 or so, it was always considered necessary to adopt more or less complicated forms of engine, gear, or boilers to arrive at high expansion; in fact, "expansion" and "expense" were at one time synonymous terms. And this should be a warning to all inventors, for there was the well-known fact that a saving of from 60 to 70 per cent. of coal could be—nay, even had at times been—effected; but, unfortunately, the many who strove to secure success to their own peculiar modes of obtaining it were barred by the complicated nature of their advances, and it was not till the present engine, which may be said to be the invention of nobody in particular, stood forth in all its simplicity that perfect success was obtained.

This present type of the compound marine engine (Plates XXI. XXII., XXIII.), may be described as a modification of the vertical or "hammer" form of screw engine, in which the screw shaft runs in a bed plate below, and the cylinders placed side by side, with the valve gear between them, are supported by brackets that are made to act as condensers, hot wells, &c. Two air pumps, worked by beams from each engine, are placed at one side, and the piston and connecting rods work direct downwards on the cranked axle, which forms the forward portion of the propeller shaft; and the modification may be broadly described as making the forward cylinder a high pressure one, exhausting into the slide case of the larger or low pressure cylinder, using a surface condenser, and

working one small air pump and one small circulating pump, by a beam attached to the high-pressure engine.

Plate XXIV. shows how the two cylinders, X and Y, are connected together, and the mode in which the steam is made to pass from one to the other. Fig. 1 is a vertical section through the line A B, Fig 2 ; and Fig. 2 is a horizontal section through the line C D Fig. 1.

It will be seen that both the high and low pressure cylinders, X and Y, are encased with jackets into which the steam enters through the pipe E on its road to the engine, communications are also made so that steam is admitted both above and below, and both cylinders are completely encased with steam.

From the jacket of the high pressure cylinder X the steam enters into the high pressure slide case F, and by means of the slide G is made to enter both above and below the piston I, exhausting into H, whence it passes by the side passages K K into the low pressure slide chest L, which distributes it above and below the piston N, and afterwards through the exhaust pipe N into the condenser.

The pistons I and N are connected to cranks, which in this instance are at right angles to each other, and it will be seen that the valves G and M have already, for some inches of the stroke, allowed the steam to pass from the small cylinder X to the large cylinder Y before the pistons arrived at their present positions. The slide of the large cylinder as shown in the plate is moving downwards, and before the piston has moved to within a quarter of the end of the stroke, it will have cut off the steam, and there will then cease to be a communication between the cylinders X and Y. This will take place after the piston I has descended rather more than a quarter of its stroke, and the slide M will continue to close both parts of the large cylinder till the piston I has reached about half its stroke. During the whole of the time the ports of the large cylinder are closed compression takes place in the small cylinder, the piston I compressing the steam remaining below it and in the passages K K and steam chest L L. This compression is shown very plainly at F, Plate XXVII., Fig. 1, D.

When the piston N gets to the end of its stroke the valve M opens the communication once more between X and Y, and the first downward impulse is given by the remainder of the steam left in X, and that contained in the passage and steam chest L, and this will enter Y at a slightly increased pressure to that at which it was cut off below N, owing to the compression before explained. When I in its turn comes to near the bottom of its stroke, the slide G will cut off the communication

between the two cylinders, and the piston N will descend by the force due to the expansion of the steam already contained between it and the cylinder cover, and when N has arrived about half way on its downward stroke, communication is established between the top of the cylinder X and the top of the cylinder Y, the fresh influx of steam sensibly increasing the pressure on the piston N, as is shown at G, Plate XXVII., Fig. 1. E.

It will be understood that by this arrangement there will be, during the time the steam in X has free access to the steam Y, an equality of pressure in the two cylinders, which will retard the motion of the piston I, while it gives motion to the piston N. This retarding pressure in X, however, is no loss, since the steam causing it is not losing its pressure so rapidly as it would have done had the small piston been stationary. The real effect of the steam being that due to the number of times the contents of the cylinder Y are greater than the contents of that portion of the cylinder X that is filled originally with steam from the boiler. A close examination of the diagrams will show also that practically there is no inconvenience or loss from this compression whatever.

There is, however, a certain loss due to the steam dispersed in the passages connecting the two cylinders and the slide case of the large cylinder, for experiments abundantly prove that by reducing their size to a minimum a decided saving is effected. It is very advantageous to give a great amount of lead to the slide of the large cylinder. For engines of the size of that represented in the Plates XXI., XXII., and XXIII., about $\frac{3}{8}$ inch lead is given to the high pressure slide, and $\frac{7}{8}$ inch to the low pressure slide.

The lap given on the high pressure cylinder will regulate the amount of steam it is desired to admit to carry out the required expansion. The steam used is measured, as it were, in the small cylinder, and the lap to the slide of the large cylinder does not vary the amount of total expansion, but it can be so arranged as to make both cylinders give out nearly equal power, which is desirable for regular working and equal wear. During the time the valve is traversing that portion of the stroke where both ports are shut, there is no communication between the two cylinders, and the compression which ensues in the small cylinder maintains the pressure and heat of the steam which is beneficial to its action in the large cylinder.

In starting, no steam can get into the large cylinder Y without first going through the small cylinder. It might so happen that with the piston I in such a position, either that its crank is on its centre or that its steam is shut off by the lap of the valve G, the engine would not

start. To obviate this inconvenience a small starting valve is used on each cylinder, that can be worked by hand; and by this means high pressure steam can be admitted at will, both to the high and low pressure cylinders, until the regular flow of steam from one cylinder to the other is effected and the engines are fairly under way. The rapidity with which the engines can be put in motion is also much increased by letting the donkey pump through the condensers, thereby causing a vacuum, which very much assists the first motion of the pistons.

The mode of settling the sizes of cylinders per nominal horse-power has, after much haggling between buyer and seller, ceased altogether to be a matter of calculation, and has settled down to 30 circular inches of piston (high and low pressure both combined) per nominal horse power. The relative contents of the high and low pressure cylinders seem to vary from one to three-and-a-half or four, and these proportions enable 30 circular inches of piston to realize four indicated horse-power, which is considered the ordinary value of one nominal horse. With the usual form of ship, it may be broadly stated that one nominal horse-power will carry ten tons of cargo at a speed of eight knots; for ships carrying above 1,000 tons the speed gradually increases say up to about 11 knots for the largest, and for ships carrying less than 1,000 tons the speed gradually decreases to about 6 knots where the proportion of one nominal horse of engine to ten tons of cargo is maintained.

It will readily be seen that this arrangement of engine possesses many advantages over the common form. For instance, the high pressure cylinder is never in direct communication with the condenser, and escapes its cooling influences; and there must be less leakage, as the steam to escape finally, must pass two pistons. O and P are two small cylinders working, in which are two pistons connected to the top ends of the two slide rods. The steam from the two steam chests has free access below these pistons, and the weight of the slides, rods, and eccentric gear is balanced.

There is nothing particular to remark on the general arrangement of the several working parts shown in Plates XXI., XXII., XXIII., further than to state generally that the whole machine is self-supporting, and rests upon a cast iron bed-plate A, the two main parts of which run fore aft, and are connected together athwart ships by four cross supports *b b b b*, in which are the four bearings that carry the cranked angle, which is usually forged in one piece in engines up to 120 nominal horse power. At the aft end of this shaft is a collar, on to which is bolted the line of shafting leading to the screw. The thrust block is usually now made

independent of the foundation plate ; it is simply made to fit a series of projecting rings, turned in that portion of the screw shafting that is near the engine room, and is easy of access.

The foundation plate is securely bolted down to sleepers built into the ship.

As most of the arrangements of the working parts are similar to those in use in all ordinary engines, no special allusion will be made to them unless to point out some modern modification suggested by practice : for instance, the use of piston rod guides on both sides has been in many cases abandoned. These guides were usually affixed on each side the piston rod to cast iron columns that supported the cylinders ; it was found, however, that the expansion of the cylinders under steam increased the distance between the columns, and consequently made a certain amount of clearance in the guides which caused a " knock " on the engine ; a single guide to each piston rod is now preferred similar to the one shown on Plate XXV., Figs. 1, 2, and 3. With this arrangement of guide, wrought iron columns are often substituted for metal columns to support the front side of the cylinders.

The surface condenser marked C, in Plates XXI., XXII., and XXIII., and which is specially shown in Plate XXVI., stands upon a raised portion of the bed plate D, Plate XXI. The water from the circulating pump G, passes through passages cast in the bed plate, into D, and thence upwards through the tubes in the direction of the arrow, Plate XXVI., Fig. 2, and afterwards through O to a pipe that conducts it through the ship's side. The steam from the low pressure cylinder passes through the exhaust pipe N, enters a sort of jacket B on the side of the condenser, and passes through the holes A among the tubes. The condensed water passes through E and F, Plate XXII., into a passage in the bed plate that conducts it to the air pump H. S is the projection to which the piston rod guides are bolted. The tubes are generally made of brass, one inch to three-quarters of an inch in diameter, about 18 wire gauge thick, and from 5 to 14 feet long.

The external surface of tube given is about 10 to $12\frac{1}{2}$ square feet per nominal horse power. There are several modes of fastening them in the tube plates. One, Fig. 3, Plate XXVI., is the mode originally proposed by Mr. Hall when the surface condensers were first invented, and consists in forming a little stuffing box *a* in the tube plate, and screwing down compressed cotton rings in the space round the tube by means of a screwed ferrule *b*. Another mode is shown in Fig. 4. A compressed and highly-dried wood ferrule *d* is driven in over the tube, and the hot

water and steam swell it out when the engine is working, and make a perfectly tight joint. A third method is to recess the tube plate on the side where the water circulates, and insert in the recess an india-rubber ring which encircles the tube, and is kept tight by the pressure of the water on the one side, and the want of atmospheric pressure on the other.

The circulating and air pumps G and H are usually made the same size, about one-eighth the contents of the high pressure cylinder, are usually placed side by side, and worked off the low pressure cylinder by a beam G'. The water, as has been before stated, is forced through and not among the tubes, and that this is the better mode of cooling the tubes has been confirmed by experience.

It is usual to make the high pressure cylinder, which is generally placed forward of the low pressure cylinder, lead, and to place the cranks at right angles. A number of very instructive experiments were made some years ago by Messrs. Palmer Brothers with a pair of engines that had the crank shaft forged in two pieces, joined in the middle by two flanges bolted together, so that the cranks could be shifted from 90 to 120 and 130 degrees. Economically no difference was found in the results, but the facilities for setting in motion and handling the engines were much greater when the cranks were at an angle of 90 degrees, and this angle has consequently been universally adopted.

Plate XXVII. contains a number of diagrams showing the action of the steam in the cylinders and on the shaft with the cranks placed at an angle of 90, 120, and 130 degrees from each other.

Fig. 1 A shows the relative position of the pistons ; Fig. 1 B that of the cranks ; Fig. 1 C shows the combined effect of both pistons on the shaft ; the irregular line *a* showing the variation of the torsional strain on the shaft at the aft end of the bed plate.

This irregular line recedes from the centre in proportion as the effective torsional strain on the shaft is increased.

The writer has been favoured, through the kindness of Mr. Frank Marshall, with indication cards taken from the steam-ship "St. Osyth," during a voyage to Melbourne, and these having been admirably reduced to diagrams representing their individual and collective action in the crank shaft by Mr. W. Sisson, are given to illustrate more thoroughly the action of the compound engine.

Fig. 1, Plate XXX., shows the cards taken from the top and bottom of the high pressure cylinder surrounded by a circle representing the stroke, and Fig. 2 shows the low pressure cards dealt with in the same way, the lines 4—12 and 0—8 being the atmospheric line of the cards.

The mode of constructing the table is as follows :—The low pressure crank leading is taken first at its bottom stroke $d o$, Fig. 2, and the high-pressure crank follows $d o$, Fig. 1. It is evident that in this position the low-pressure piston is doing no work, but the high-pressure piston is descending, its crank being at $d o = 2.125$ feet in its most effective position (the angle made by the connecting rod being disregarded), and its pressure on the crank being $r o' = 36$ lbs.

The torsional strain on the shaft will therefore be represented by $36 \times 2.125 = 76.5$. (See Table II.)

Let the cranks now move on to $d 1$ in both figures. The strain on the shaft will be made up by $o k$, Fig. 2; the pressure at that point into $a 1$, the effective leverage of the crank from the low-pressure piston, and by $z n$, Fig. 2, the pressure, and $c 1$ the effective leverage of the high-pressure piston.

It should be here remarked that the total effective effort of the low pressure piston must be multiplied by 3.4 as the low pressure piston is 3.4 times as large as the high pressure piston.

By taking all the other positions of the crank in succession in the same way, the Table, No. 2 has been constructed.

It will be observed that there are certain minus quantities given in the table, and these require some explanation.

A large amount of level, it has been observed, has to be given to the valves, and this of course produces a certain amount of cushioning, which has its advantages in checking the piston at the end of each stroke, but which nevertheless acts against the pressure on the shaft.

If the position $d 3$, Fig. 2, of the crank is taken it will be seen that the propelling pressure $i k$ is counteracted by an impeding pressure $j k$ on the other side of the piston, the total impeding pressure being $i j$, which equals in this case 18 lbs.

For the same reason when the crank is at $d 2$, Fig. 1, $p m$ must be considered the pressure, and not $p l$, $l m$ being a retarding pressure.

In Plate XXXI. all these various pressures are measured off on radii subtending sixteen equal divisions of the circle to a scale of one inch for every 36 units, given in column 8 of the table.

The curved strong line shows the varying effort made by the engines to turn the shaft, the dotted line shows what that effort would have been had there been no compression through excessive load, and the circle shows the average effort.

TABLE II.
SHOWING PRESSURES IN BOTH HIGH AND LOW PRESSURE CYLINDERS AND TORSIONAL STRAINS AT 16 PORTIONS OF THE STROKE.

1.	2.	3.	4.	5.	6.	7.	8.
No	Pressure from Diagrams.		Effective Leverages.		Relative Turning Effect of High.	Relative Turning Effect of Low.	Turning Effect of both Cylinders.
	High.	Low.	High.	Low.			
0	<i>r o'</i> 36	<i>q' k'</i> 15	<i>d</i> 0 2 1½	ft. in. 0 0	<i>lbs.</i> 36 × 2½25 = 76½	<i>Feet.</i>	<i>Ft. lbs.</i> 76½
1	<i>z n</i> 24	<i>o k</i> 15	<i>e</i> 1 1 11½	<i>a i</i> 0 9½	24 × 1·96 = 47.	15 × 3·4 × 0·8 =	88.
2	<i>h m</i> 13	<i>p l</i> 12	<i>b</i> 2 1 6	<i>b</i> 2 1 6	13 × 1·5 = 19·5	12 × " × 1·5 =	80½
3	<i>j i</i> -18	<i>n</i> 10	<i>a</i> 3 0 9½	<i>c</i> 3 1 11½	-18 × 0·8 = -14·5	10 × " × 1·96 =	52.
4	<i>q' k'</i> 53	<i>r o'</i> 8	0 0	<i>d</i> 4 2 1½	... ..	8 × " × 2½25 =	58.
5	<i>o k</i> 52	<i>s p'</i> 5	<i>a</i> 5 0 9½	<i>e</i> 5 1 11½	52 × 0·8 = 41·5	5 × " × 1·96 =	74·75
6	<i>p l</i> 48	<i>t r'</i> 2	<i>b</i> 6 1 6	<i>f</i> 6 1 6	48 × 1·5 = 72·0	2 × " × 1·5 =	82·2
7	<i>q n</i> 41	<i>u r'</i> -4½	<i>e</i> 7 1 11½	<i>g</i> 7 0 9½	41 × 1·96 = 80·5	-4½ × " × 0·8 =	68·25
8	<i>r o'</i> 36	<i>w' e'</i> 16	<i>d</i> 8 2 1½	0 0	36 × 2½25 = 76½	... ..	76½
9	<i>s p'</i> 22	<i>w s'</i> 15	<i>e</i> 9 1 11½	<i>g</i> 9 0 9½	22 × 1·96 = 43.	15 × " × 0·8 =	84.
10	<i>t r'</i> 12	<i>x q'</i> 14	<i>f</i> 10 1 6	<i>f</i> 10 1 6	12 × 1·5 = 18.	14 × " × 1·5 =	89·5
11	<i>u r</i> -21	<i>y p'</i> 13	<i>g</i> 11 0 9½	<i>e</i> 11 1 11½	-21 × 0·8 = -16·75	13 × " × 1·96 =	69·75
12	<i>w' e'</i> 55	<i>r o'</i> 10	0 0	<i>d</i> 12 2 1½	... ..	10 × " × 2½25 =	72·25
13	<i>w s'</i> 55	<i>z n</i> 7½	<i>g</i> 13 0 9½	<i>e</i> 13 1 11½	55 × 0·8 = 44.	7½ × " × 1·96 =	94.
14	<i>x q'</i> 52	<i>h l</i> 4½	<i>f</i> 14 1 6	<i>b</i> 14 1 6	52 × 1·5 = 78.	4½ × " × 1·5 =	101.
15	<i>y p'</i> 44	<i>j i</i> -3	<i>e</i> 15 1 11½	<i>a</i> 15 0 9½	44 × 1·96 = 86·25	-3 × " × 0·8 =	78·25
							1245·40

Mr. Holt, of Liverpool, has constructed many engines with the high pressure cylinder over the low pressure one, the pistons of which are connected together with one piston rod, thereby giving but one impulse to a single crank, and has obtained some very good results with the arrangement; but the torsion diagram, Fig. 4 C, Plate XXVII., is not a desirable one, and the difficulties that attend starting engines so constructed render the arrangement inadvisable.

The writer was asked to name the quantity of water required to condense the steam required for such a class of engine using surface condensers. The usual practice is to allow a quantity equal to one-eighth the contents of the small cylinder, and this seems sufficient under ordinary circumstances at sea.

Theoretically, a little over half this quantity of water at 60 degrees would reduce all the steam used at 75 lbs. above the atmosphere, and cut off at three-quarters of the stroke in the high pressure cylinder to water at 110 degrees.

Steam at 75 + 15 lbs. above zero has a visible temperature of 322 degrees, and a volume of 323 (latent heat, 888).

Take the contents of the high pressure cylinder at 8 cubic feet, and the steam used as 6 cubic feet, this would equal $\frac{6}{3\frac{2}{3}} \times 2 = .0371$ cubic feet of water per double stroke reduced from 322 degrees + 888 degrees = 1,210 degrees to 110 = 1,100 degrees, which is equivalent to raising

$$\frac{1,100 \text{ degrees}}{110 \text{ degrees} - 60 \text{ degrees}} = 22 \text{ times the bulk of water } (110^\circ - 60^\circ)$$

$$= 50^\circ : .0371 \times 22 = .8162 \text{ of a cubic foot, which is nearly the}$$

 cubic foot, the proportion of one-eighth the low pressure cylinder would give.

Plates XXVIII. and XXIX. show the usual form of boilers employed for this class of engine. They are necessarily of very large diameter, and require great care in their construction, to enable them to carry such pressure as 80 to 90 lbs. above zero. The plates of the shell are usually made to butt together, so as to keep the shape of the outside perfectly circular. These butt joints are secured by straps on each side the plates, double rivetted to each plate.

The fire tubes are usually made in two plates, the top plate being brought well down below the fire, but sometimes they are welded up into rings, and these rings are flanged and a piece of plate rivetted between the flanges.

The doors to the fire tubes are generally perforated and provided with a sliding plate to regulate the admission of air for the prevention of smoke,

and very often arrangements are made for admitting air at C, behind the fire bars for the same purpose. The small tubes are about $3\frac{1}{4}$ inches outside diameter and about $\frac{1}{8}$ inch thick, and are often only man-drilled into the tube plates. A fair average heating surface is 20 square feet per nominal horse power, this includes the fire tubes above the bars, the whole of the back take-up, and the whole of the small tubes and front of the boiler inside the smoke box to water line. The smoke box is dry, that is not surrounded with water; it is distinct from the boiler, and is made of thin plates so arranged that a current of air may pass between them and keep down the temperature.

Superheaters are sometimes placed in the take-up through which the steam passes to the cylinders.

The worst feature in these boilers is the want of circulation, which prevents the water from becoming heated at the bottom between the furnaces, this has a tendency to destroy the boiler by the unequal expansion that it causes. To obviate this as much as possible, only one fire should be lighted at a time in first getting up steam, and then as the other fires are lighted, and steam partly raised, a quantity of the cold water should be blown out to be replaced by the warm water above the fire tubes. Even when the engine and boilers are in regular work, it is desirable to blow out the boilers at least twice a day, to keep up the heat at the bottom.

The effects of the galvanic action between the boilers and the condenser tubes is obviated either by allowing the boilers to become slightly crusted over with deposit at first, or by coating them over with lime-wash before they are used. A better mode, however, is to introduce pieces of zinc Z Z, Plates XXVIII. and XXIX.; about two cwt. of zinc being sufficient to keep a large boiler free from injury for two or three months.

THE STRENGTH OF MARINE BOILERS.

These boilers, if for use in steamers carrying the British flag, have to be built under the inspection of the Board of Trade Surveyors.

There are no generally recognised rules for the guidance of these gentlemen, and before building a boiler the manufacturer would do well to show the design to the surveyor of the district and obtain his approbation of the mode in which it is proposed to stay the boiler and the thickness of plates to be used.

Although there are no general rules adopted by the Board of Trade, yet it is generally considered that the following memoranda contain, to a certain extent, the data upon which the passing of the boiler by the surveyor depends :—

When boilers are made of the best material, with all the rivet holes drilled in place, and all the seams fitted with double-butt straps of at least five-eighths the thickness of the plates they cover, and all the seams at least double rivetted with rivets having an allowance of not more than 50 per cent. over the single shear, and provided that the boilers have been open to inspection during the whole period of construction, then 6 may be used as the factor of safety. But the boilers must be tested by hydraulic pressure to twice the working pressure, in the presence and to the satisfaction of the Board's Surveyor.

But when the above conditions are not complied with, the additions in the following scale must be added to the factor 6, according to the circumstances of each case :—

- A ·15.—To be added when all the holes are fair and good in the longitudinal seams, but drilled out of place after bending.
- B ·3.—To be added when all the holes are fair and good in the longitudinal seams, but drilled out of place before bending.
- C ·3.—To be added when all the holes are fair and good in the longitudinal seams, but punched after bending instead of drilled.
- D ·5.—To be added when all the holes are fair and good in the longitudinal seams, but punched before bending.
- E* ·75.—To be added when all the holes are not fair and good in the longitudinal seams.
- F ·1.—To be added if the holes are all fair and good in the circumferential seams, but drilled out of place after bending.
- G ·15.—To be added if the holes are fair and good in the circumferential seams, but drilled before bending.
- H ·15.—To be added if the holes are fair and good in the circumferential seams, but punched after bending.
- I ·2.—To be added if the holes are fair and good in the circumferential seams, but punched before bending.
- J* ·2.—To be added if the holes are not fair and good in the circumferential seams.
- K ·2.—To be added if double-butt straps are not fitted to the longitudinal seams, and the said seams are lap and double rivetted.
- L ·1.—To be added if double-butt straps are not fitted to the longitudinal seams, and the said seams are lap and treble rivetted.
- M ·3.—To be added if only single-butt straps are fitted to the longitudinal seams, and the said seams are double rivetted.
- N ·15.—To be added if only single-butt straps are fitted to the longitudinal seams, and the said seams are treble rivetted.

- O .1.—To be added when any description of joint in the longitudinal seams is single rivetted.
- P .1.—To be added if the circumferential seams are fitted with single-butt straps, and are double rivetted.
- Q .2.—To be added if the circumferential seams are fitted with single-butt straps, and are single rivetted.
- R .1.—To be added if the circumferential seams are fitted with double-butt straps, and single rivetted.
- S .1.—To be added if the circumferential seams are lap joints, and are double rivetted.
- T .2.—To be added if the circumferential seams are lap joints, and are single rivetted.
- U .25.—To be added when the circumferential seams are lap, and the streaks or plates are not entirely under or over.
- V .3.—To be added when the circumferential seams are not fitted with double-butt straps and double rivetted. When the boiler is of such a length as to fire from both ends, or is of unusual length, such as flue boilers.
- W* .4.—To be added if the seams are not properly crossed.
- X* .4.—To be added where the iron is in any way doubtful, and the surveyor is not satisfied that it is of the best quality.
- Y 1.65.—To be added if the boiler is not open to inspection during the whole period of its construction.

Where marked thus* the allowances may be increased still further if the workmanship or material is very doubtful or very unsatisfactory.

The strength of the joints is found by the following method:—

$$\frac{(\text{Pitch} - \text{Diameter of Rivets}) \times 100}{\text{Pitch}} = \begin{cases} \text{Percentage of strength of plate} \\ \text{at joint as compared with} \\ \text{the solid plate.} \end{cases}$$

$$\frac{(\text{Area of Rivets} \times \text{No. of rows of Rivets} \times 100)}{\text{Pitch} \times \text{thickness of plate}} = \begin{cases} \text{Percentage of} \\ \text{strength of rivets} \\ \text{as compared with} \\ \text{the solid plate.} \end{cases} \dagger$$

Then take iron as equal to 23 tons, and use the smallest of the two percentages as the strength of the joint, and adopt the factor of safety as found from the scale given in this circular:—

$$\frac{(51,520 \times \text{percentage of strength of joint}) \times \text{twice thickness of the plate in inches}}{\text{Inside diameter of the boiler in inches} \times \text{factor of safety}} = \begin{cases} \text{Pressure to be} \\ \text{allowed per} \\ \text{square inch on} \\ \text{safety valves.} \end{cases}$$

† If the rivets are exposed to double shear, multiply the percentage as found by 1.5.

Plates that are drilled in place must be taken apart, and the burr taken off, and the holes slightly countersunk from the outsides. Butt straps must be cut from plates (and not from bars), and must be of as good a quality as the shell plates, and for the longitudinal seams must be cut across the fibre. The rivet holes may be punched or drilled when the plates are punched or drilled out of place. When single butt straps are used, and the rivet holes in them punched, they must be one-eighth thicker than the plates they cover. The diameter of the rivets must not be less than the thickness of the plates of which the shell is made, but it will be found when the plates are thin, or when lap-joints or single-butt straps are adopted, that the diameter of the rivets should be in excess of the thickness of the plates.

STRENGTH OF FURNACES.

$$\frac{\text{If butt straps are used, } 90,000 \times T^2}{L + 1 \text{ (diameter of furnace in inches)}} = \begin{cases} \text{working} \\ \text{pressure.} \end{cases}$$

L = Length of furnace in feet.

T = Thickness of plate.

For ordinary overlap joints the co-efficient is 70,000 instead of 90,000.

The length of furnace is measured at the bottom to end of combustion chamber, or to tube plate if the bottom of furnace is stayed.

STAYS.

$$\frac{5,000 \times \text{area of stay}}{\text{Working pressure.}} = \begin{cases} \text{product of distance of stays both} \\ \text{ways from centre to centre.} \end{cases}$$

The following are examples of the mode of carrying out these data :—

Take a boiler 13 ft. $6\frac{1}{2}$ in. diam., with 1 in. plates, double rivetted with inch rivets spaced $2\frac{1}{2}$ in. from centre to centre, the transverse strength of a square inch of the plates being 51,520 lbs. Then the boiler to be constructed of the best material, and in all respects entitled to the factor 6, as explained above.

$$\frac{(2\frac{1}{2}-1) \times 100}{2\frac{1}{2}} = 60$$

Or the strength of the plate through the joint will be 60% of the solid material, and,

$$\frac{.7854 \times 2 \times 100}{2\frac{1}{2} \times 1} = 62.8$$

Or the strength of the rivets will be 62.82 % of the solid material.

Then

$$\frac{51,520 \text{ lbs.} \times .60 \times 2}{13.5 \times 12 \times 6} = 63.6$$

A boiler of these dimensions and strengths would be allowed by the Board if made to carry a pressure of 63.6 lbs. to the square inch.

Referring to Fairbairn's "Useful Information for Engineers," Page 34, it will be seen to be there stated that the strength of double-rivettcd joints is 70 per cent. of the solid plate.

The ultimate strength of the boiler will be according to this—

$$\frac{51520 \times .70 \times 2}{13.5 \times 12} = 445 \text{ lbs.}$$

According, therefore, to the Board of Trade regulations, the working load of the boiler would be one-seventh of its ultimate strength.

With regard to the strength of the furnaces, the application of the rule of the Board of Trade for a furnace 38 inches, diameter, 7-16ths thick, and 6 feet 9 inches long, would give

$$\frac{90,000 \times .4375^2}{6.75 + 1(38)} = 58.5$$

As the pressure.

Referring again to Fairbairn, Page 45, the following formula for boiler tubes is given :—

$$P = 806,300 \frac{K^{2.19}}{L.D}$$

Where P is the collapsing pressure in lbs., K thickness of plates in inches, L length of the tube in feet, and D diameter in inches, and this applied to the above case gives

$$\frac{806,300 \times .437^{2.19}}{6.75 \times 38} = 512 \text{ lbs.}$$

As the ultimate strength of the tube.

According, therefore, to the Board of Trade regulations, the ultimate strength of this tube would be 8.7 times its working pressure.

The writer would suggest in conclusion that the compound engine seems peculiarly suitable for winding coal. Mining engineers are often heard to express a preference for the single Crowther engine over double horizontal engines, because the whole pressure of the steam can be put on the larger area of the piston of the single engine when that engine is at the most advantageous part of its stroke, whereas the only one of the double engines is in a position to give out its full power at the commencement of the lift. The Crowther engine

is considered, therefore, more rapid in its action. For this reason, when two engines are used for winding, the united areas of their pistons should be more than the area of one piston to do the same work. Now, the compound engine would have a gross area of piston about equal to the single engine, and could be easily arranged so that the low pressure piston should be at half-stroke when the lift commences, and the brakesman could with the starting valve put the full force of the high pressure steam upon the larger piston to commence with. This would at once put the load in rapid motion, and the engine would immediately after commence its expansive action.

The writer, in his anxiety to prevent a second postponement of a general meeting, imposed upon himself he fears too heavy a task. The subject is so vast and so important that it should have been handled with an amount of reflection that he has been utterly unable to give to it in these exciting times of arbitration.

He would express his most sincere thanks to Mr. Frank Marshall, of Messrs. R. & W. Hawthorn & Co., whose very kind and intelligent assistance in getting up the drawings and diagrams alone made the attempt at producing the paper possible. The author is also indebted to Mr. Thos. Hawthorn, Mr. Jacob Wallau, Mr. A. G. Schaeffer, and Mr. W. Sisson, for much valuable information.

Mr. SIMPSON said, he would like to ask Mr. Bunning or any gentleman present, conversant with marine engines, if they had tried any experiments as to the benefit, or otherwise, of jacketing the cylinder? He believed there had been a great deal of discussion on that point, as to whether there was advantage in it or not. Some said there was great advantage and others that there was none. He was very much interested in the subject, for he had tried on colliery engines jacketed cylinders, but he had never yet been able to demonstrate to his own satisfaction how much benefit was due to the jacketing of the cylinder, although practically, the result of the work of the engines was most satisfactory, but whether that was due to other parts of the engine or not he was not prepared to state. He would like very much to know whether any experiments had been made definitely to show whether jacketing was of the great advantage which some people stated it to be. He believed it had been stated to be as high as 20 per cent. He would also like to ask a question as to the friction of a marine engine, or of a double engine, as compared with a single engine.

Mr. BUNNING said, with regard to jacketing the cylinders, of course they all knew there was a positive advantage in using steam expansively. They knew the law which governs expansion ; and they knew that the more they expand steam theoretically, the more economical would be the effect obtained. The old fashioned engines—used in Her Majesty's Navy—were always fitted with expansion valves. These expansion valves were arranged so that they could, if they liked, give them a very high amount of expansion. But they very soon found that when they gave them more than a certain amount of expansion, they actually got a worse effect. Now that simply arose from the fact that the cylinders were not jacketed ; consequently, when the expansion brought the steam down at the end or towards the end of the stroke, a considerable amount of pressure was lost by condensation, and the benefit of the expansion was done away with. He thought he could not answer Mr. Simpson's question better than by simply stating this fact, that these engines were unable to take advantage so fully as they otherwise would have done of their expansive valves, because of the condensation which took place from their unjacketed cylinders.

Mr. SIMPSON said, he could quite understand that in an expansive cylinder when steam was expanded, heat was lost, and that, therefore, the jacket was beneficial ; but he would like to know if the same thing happened in a high pressure cylinder when the steam was not expanded, whether any practical economical result from the jacketing was obtained.

Mr. WILLIAM BOYD said, he understood that the discussion on this paper was to a certain extent premature. Mr. Bunning announced the paper as being a few notes put together, which he hoped to present to them in a more elaborate form in the next part issued. With the view of promoting what he thought might be a very interesting discussion, he proposed that it be adjourned to some future day. With regard to the question Mr. Simpson had just asked, without going into the theoretical advantage or disadvantage of jacketing cylinders, he might mention one case which had come within his own experience, and which he thought pretty well answered the question, though he had no doubt other gentlemen could produce other examples of a diametrically opposite result. The case was this :—A pair of 200 horse power engines made a voyage to India and back again, with high pressure cylinder jacketed. The jacket was used the whole of the voyage for this reason, that it formed part of the steam pipe through which the steam must pass on its way to the steam chest. These jacketed cylinders, he might tell them,

were very difficult to cast, and during the voyage part of the casting cracked, and the high pressure cylinder had to be replaced at the end of the first voyage with another one. The owners were so alarmed at the idea of having another cracked cylinder, that they determined to abandon what they believed to be then the advantage of the jacketed cylinder, and a second cylinder was cast without jackets. The ship made a second voyage to India, carrying the same cargo, and presumably meeting on the average with much the same sort of weather. She made the voyage in exactly the same time, burnt exactly the same quantity of coal, and carried the same cargo the whole of the way. In one case she had a jacketed cylinder, and in the other case she had not.

Mr. SIMPSON would like to ask Mr. Bunning another question. They were very much interested in the kind of boiler to use about collieries. Mr. Bunning was proposing to use marine engines for mining engines with regard to economy; and he would like to know what was the life of one of these boilers, supposing of course it did not get drowned?

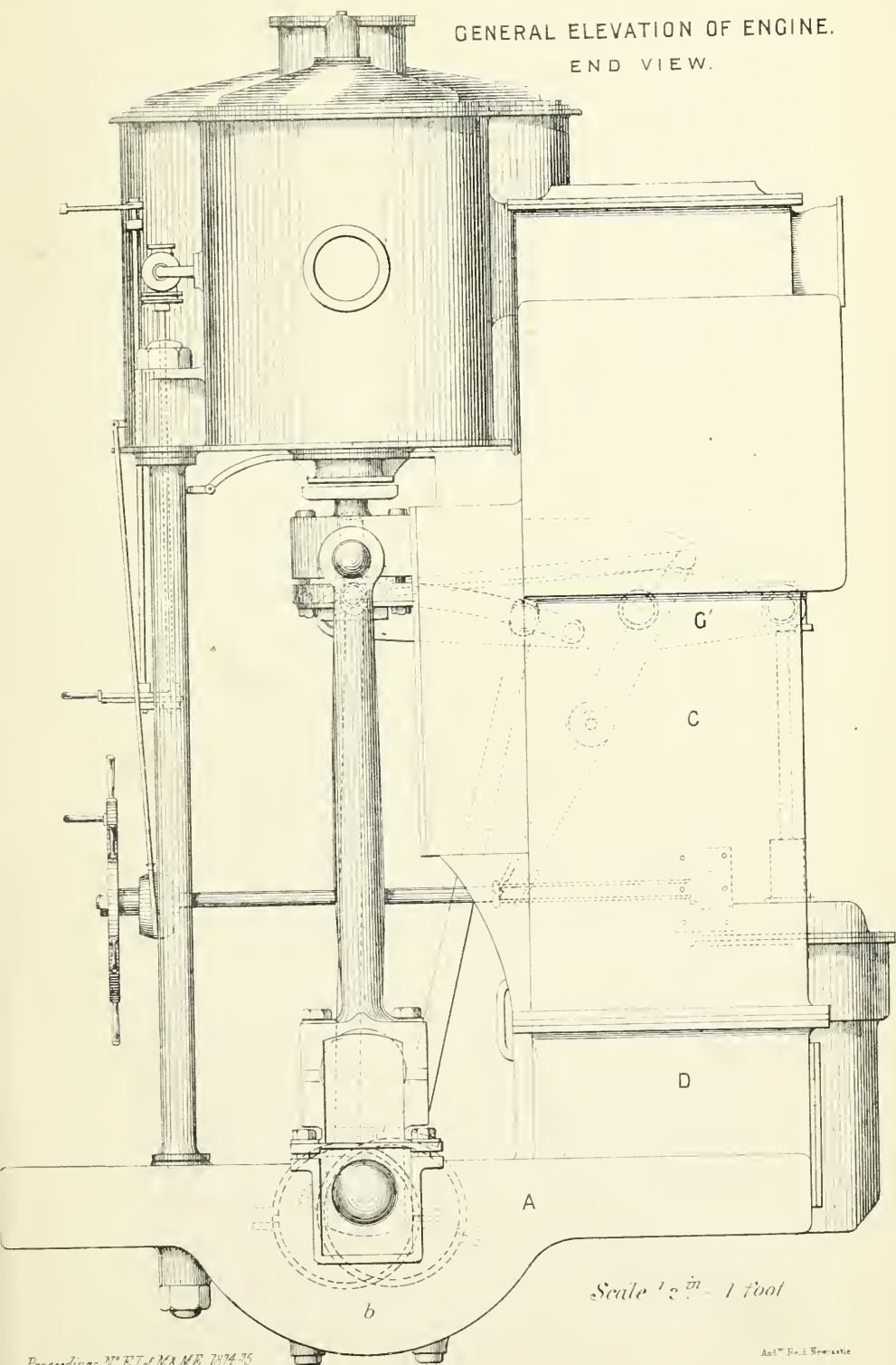
Mr. BUNNING said, if they adopted the engine they might adopt any class of boiler they thought most suited to their peculiar purposes. The Lancashire boiler was almost identical with the marine boiler described, except that flues were substituted for small tubes; the internal firing and circular fire tube were the same in both. He thought the Lancashire boiler was the most perfect boiler for colliery and for other purposes on land. Of course it could not be used on board ship, for it would necessitate the use of brick work, but it would work well with the compound engine for all pit purposes. It would not be always necessary to use surface condensers if the water was suitable without.

Mr. SIMPSON said that Mr. Bunning had made a statement as to applying one of these marine engines for the winding engines of collieries. The great difficulty he (Mr. Simpson) saw about them was in starting from the bottom of the pit. The full power of the engine would not be on, so that a much greater engine would be required than was necessary to lift the load than in an ordinary engine; and with the compound engine the smaller cylinder would have to be sufficiently powerful to do the work to begin with.

Mr. BUNNING—On the contrary, the drum could be so arranged that the large piston would be at half stroke, and, therefore, in its most powerful position, when the load was first lifted and the high pressure steam could be applied direct to it by means of the starting valve, then as soon as the load was in motion the expansive process would immediately commence.

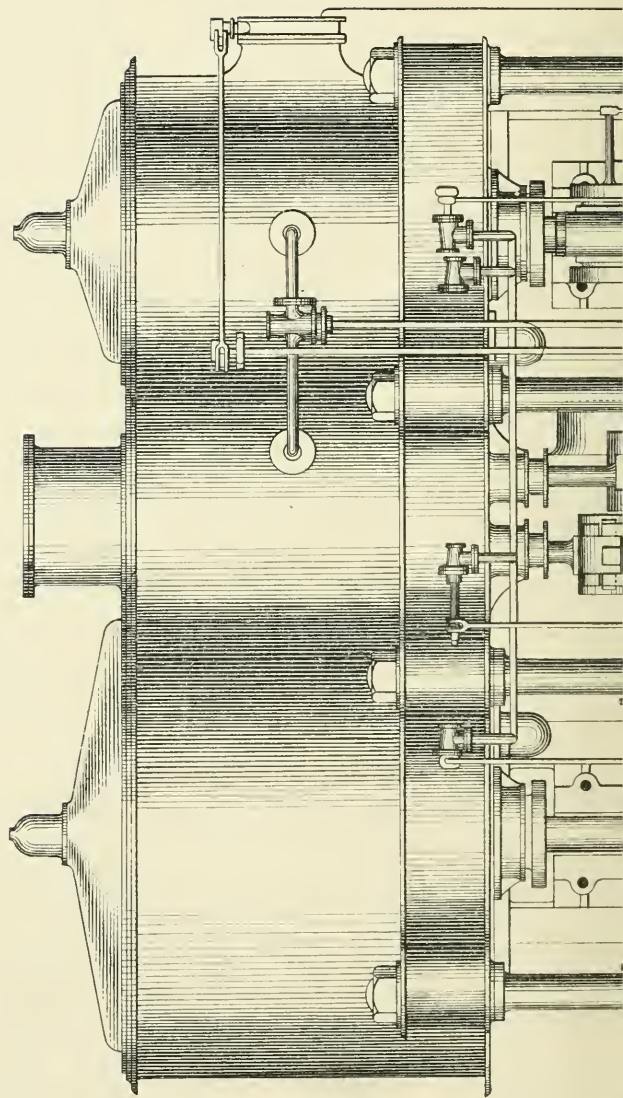
To illustrate Mr Theo. Wood Bunnings paper on the Marine Engine.

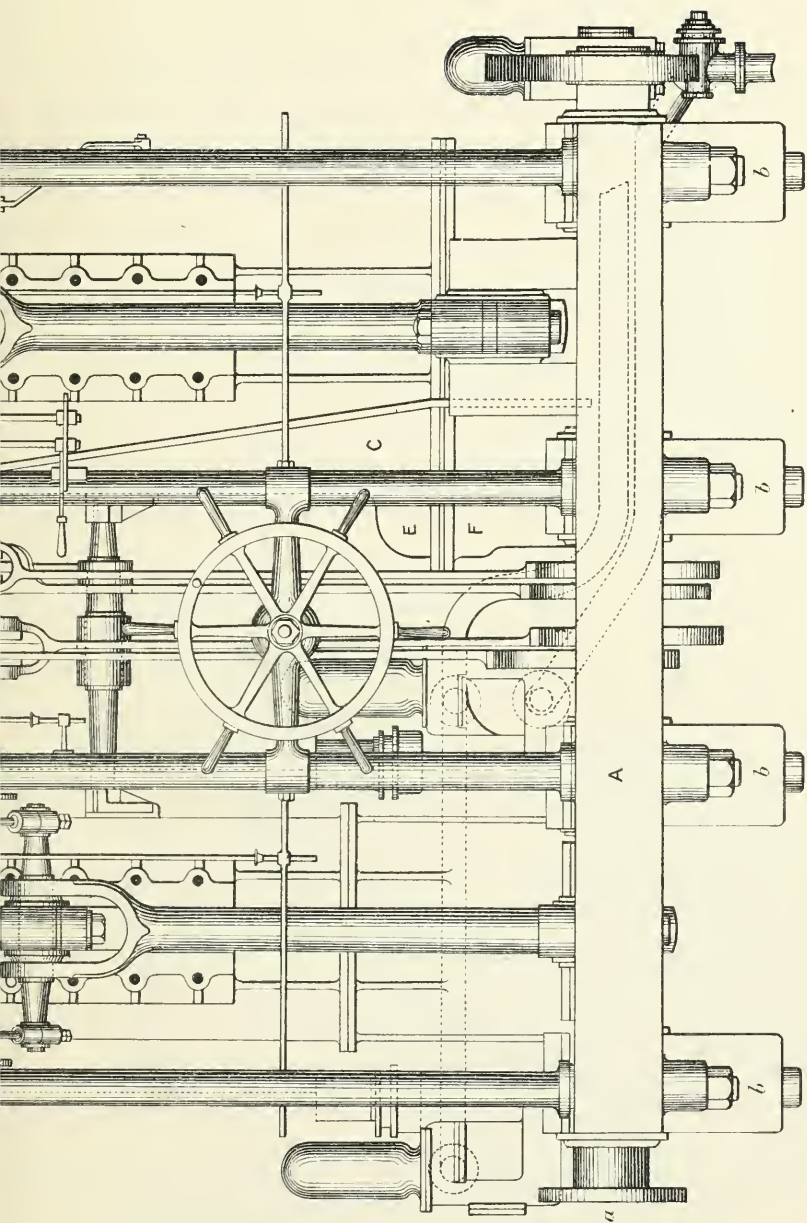
GENERAL ELEVATION OF ENGINE.
END VIEW.



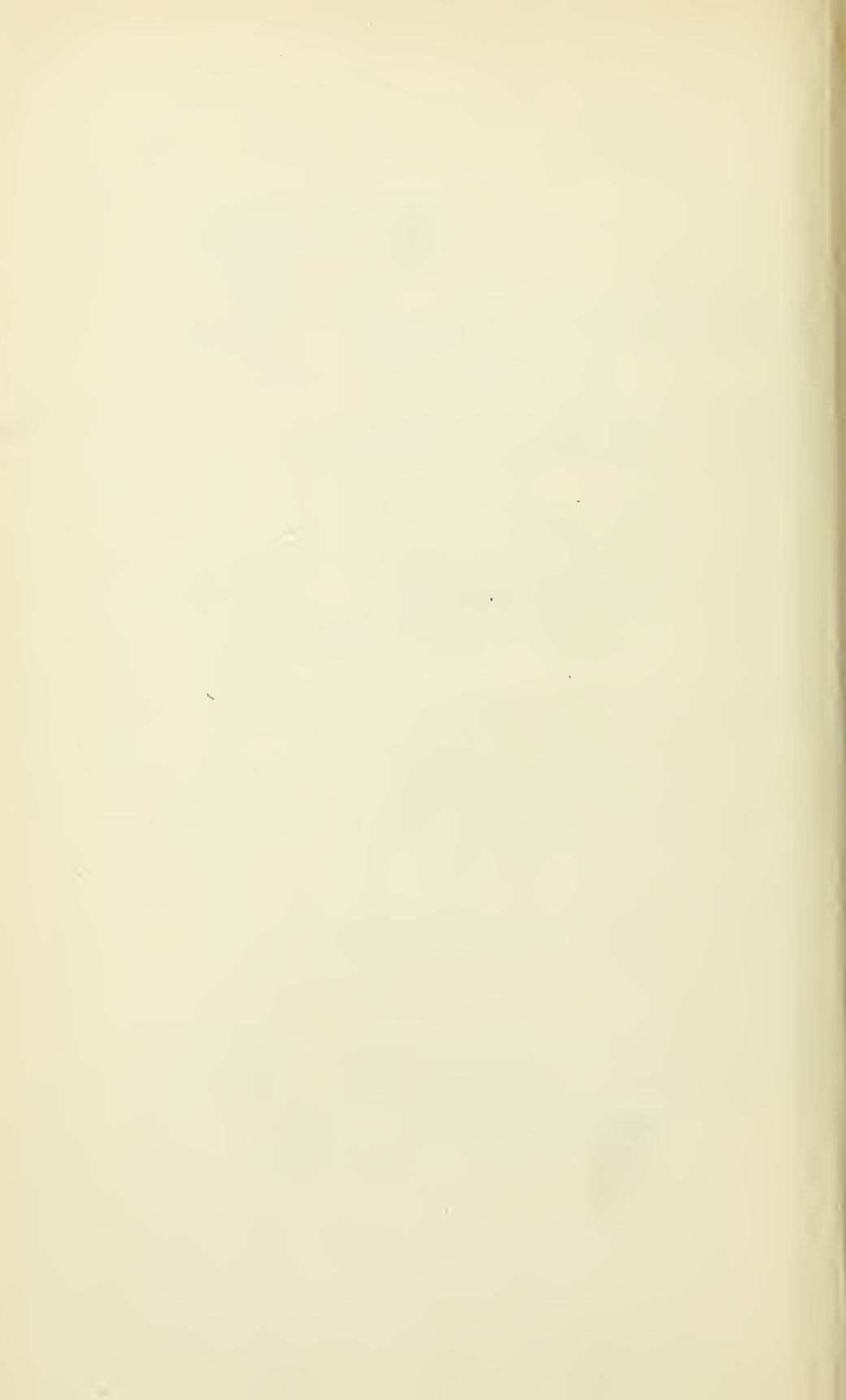
To illustrate Mr. Theo. Wood Bunnings' paper on the "Marine Engine."

GENERAL ELEVATION OF ENGINE, FRONT VIEW.



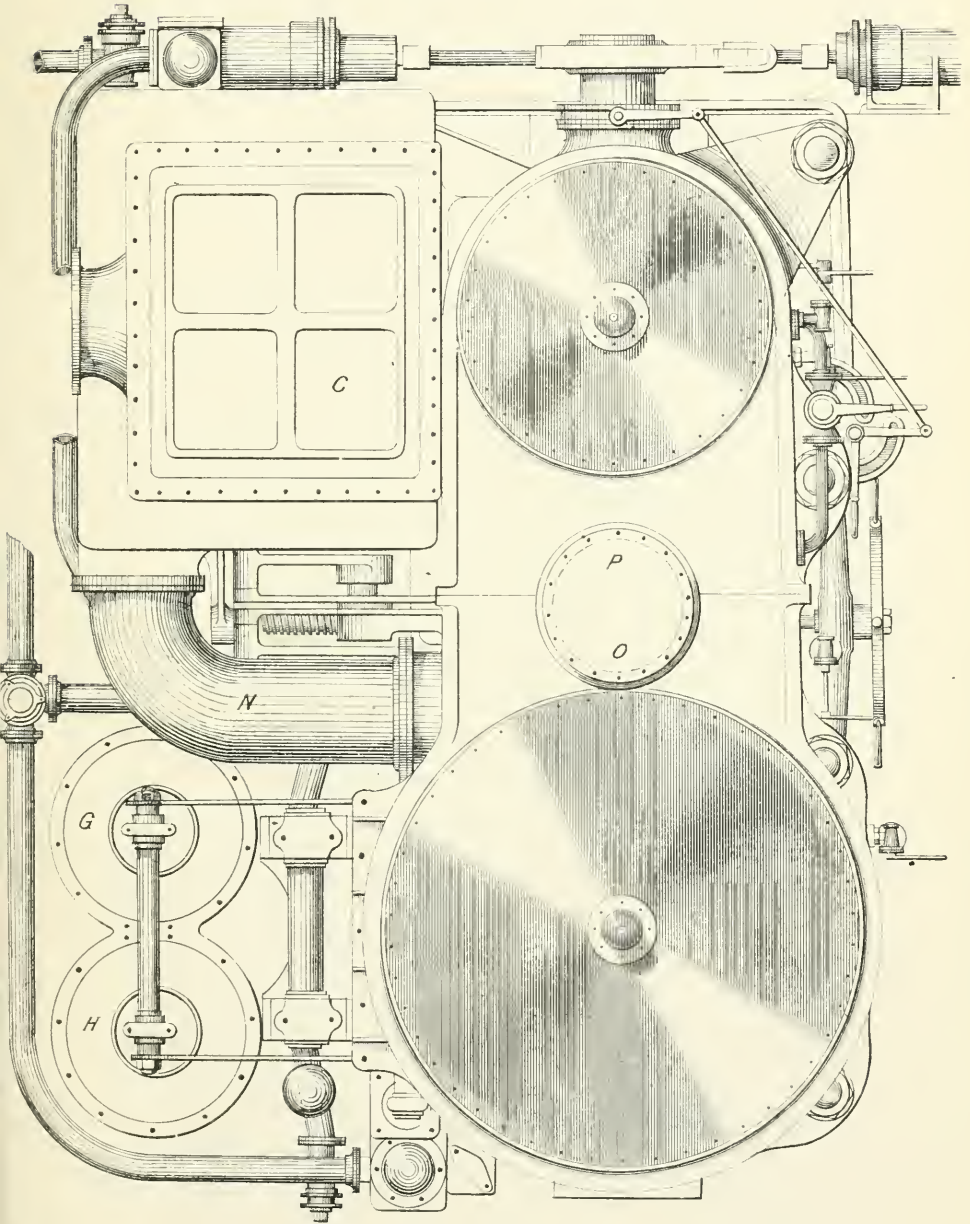


Scale $\frac{1}{2}$ inch = 1 foot.



To illustrate Mr Theo Wood Bunnings paper on the "Marine Engine"

PLAN OF ENGINE

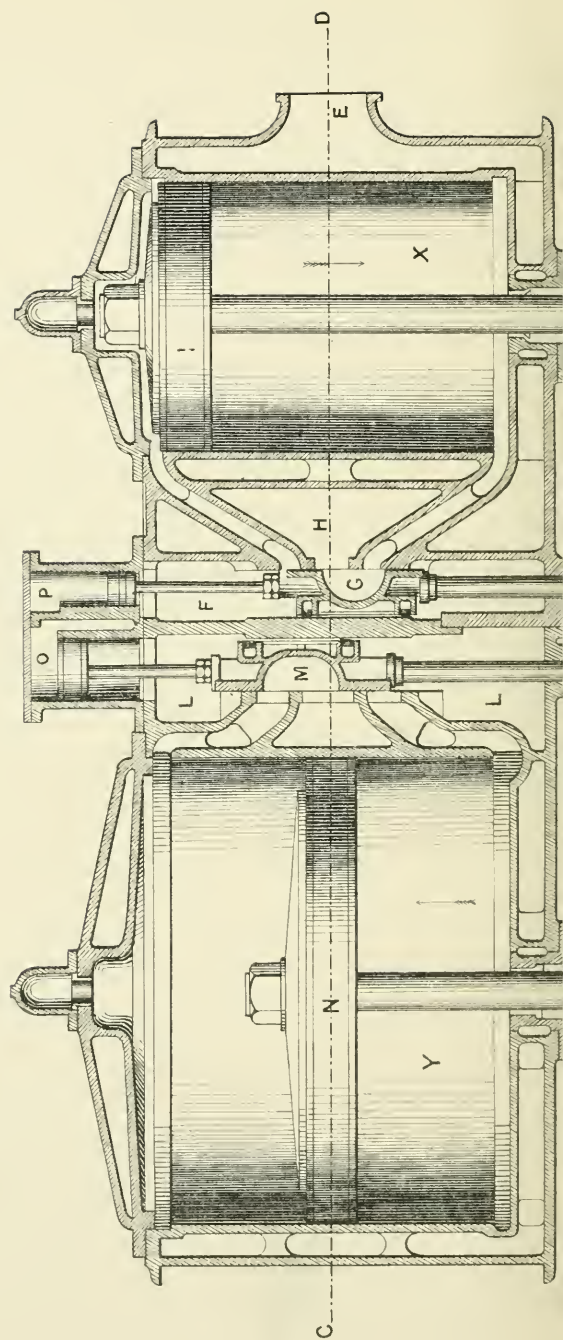


Scale $\frac{1}{2}^m$ 1 foot

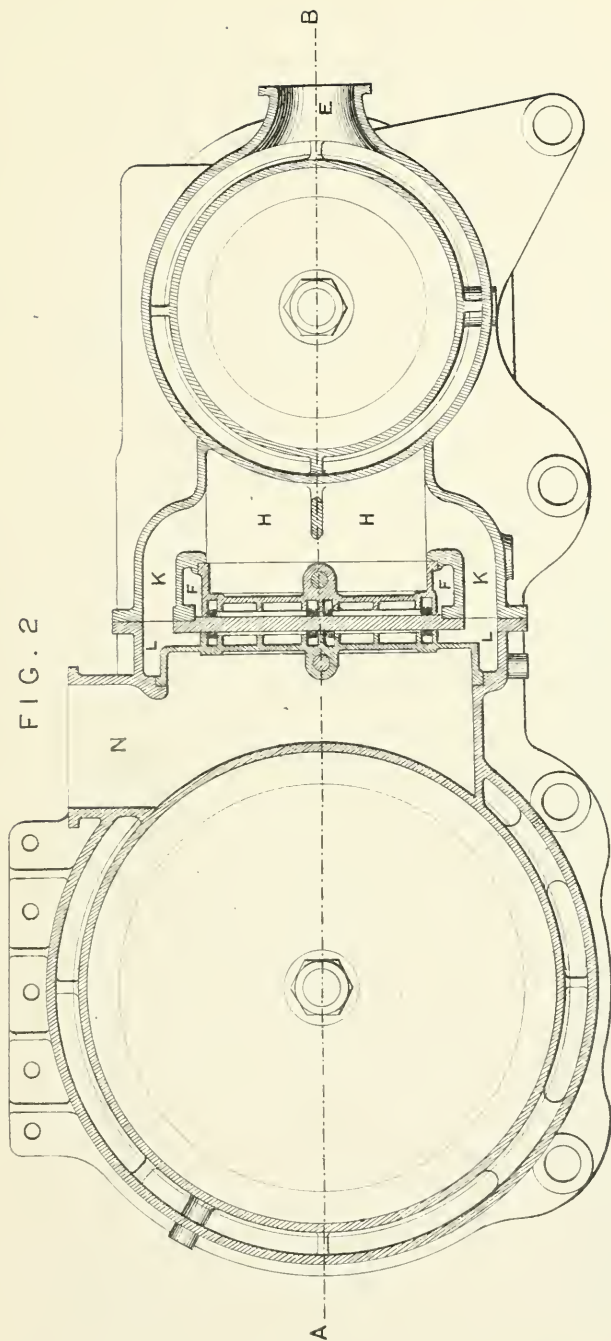
To illustrate Mr. Theo. Wood Bunnings's paper on the Marine Engine.

SECTIONAL ELEVATION OF CYLINDERS.

FIG. 1



Scale $\frac{1}{2}$ inch = 1 foot.



SECTIONAL PLAN.

To illustrate M^r Theo. Wood Bunnings's paper on the "Marine Engine".

GUIDE CLIP FOR PISTON ROD.

Fig. 1



Fig. 2

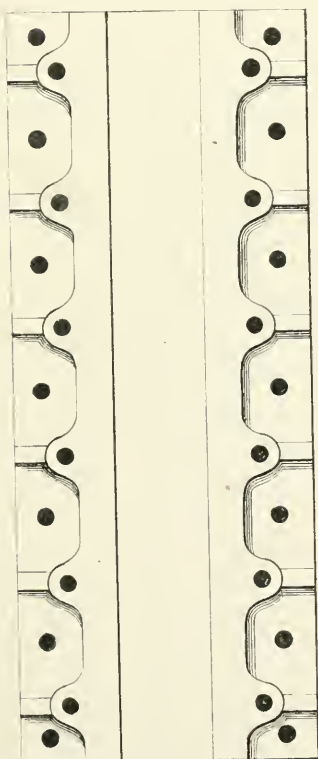
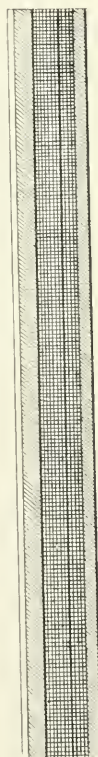


Fig. 3



Scale 1 in. = 1 foot

To illustrate Mr Theo Wood Bunnings paper on the "Marine Engine".

FIG: 1 N

Scale $\frac{1}{2}$ in = 1 foot

Section through O.T. Fig 2.

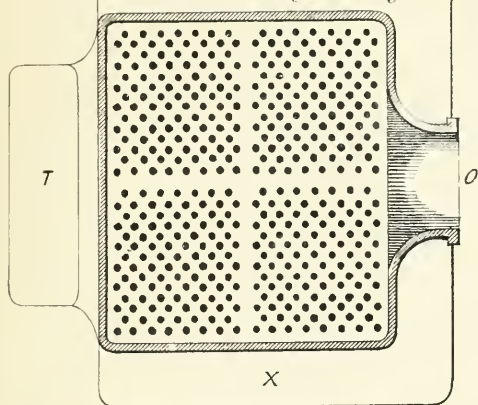
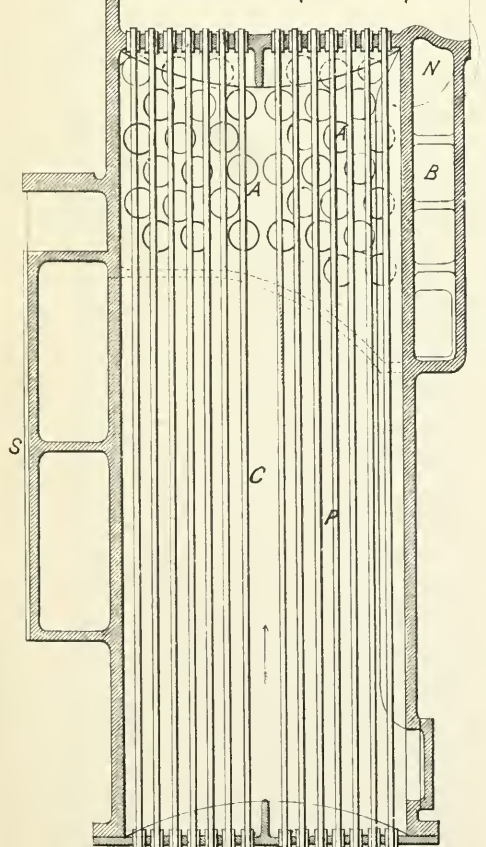


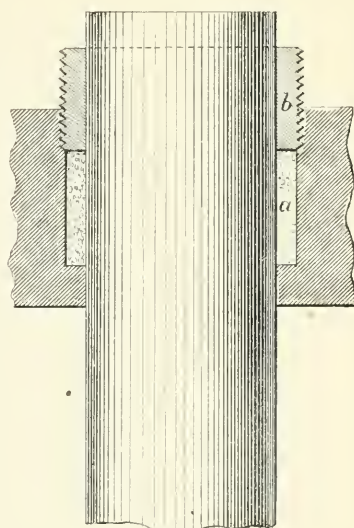
FIG: 2

Section through O.T. Fig. 1.



ELEVATION

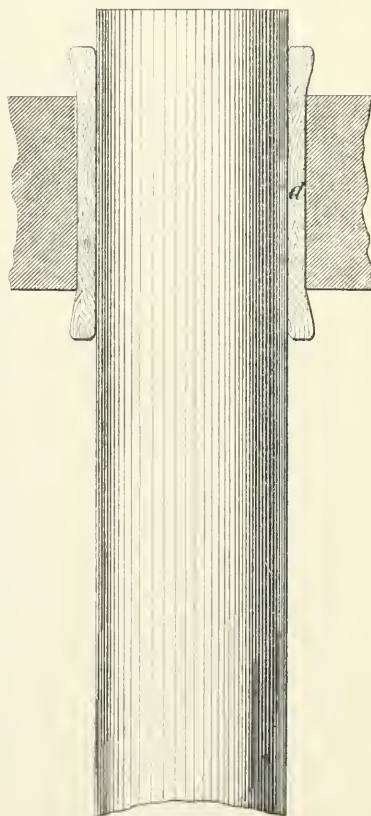
FIG: 3



Full Size

Condenser and Tubes.

FIG: 4



Full Size

To illustrate Mr. Theo. Wood Bunnings's paper on the "Marine Engine."

Fig 1 A.

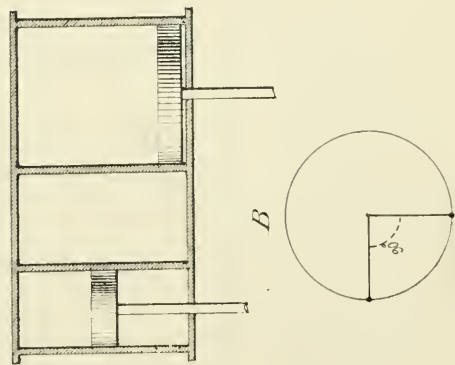


Fig 2, A.

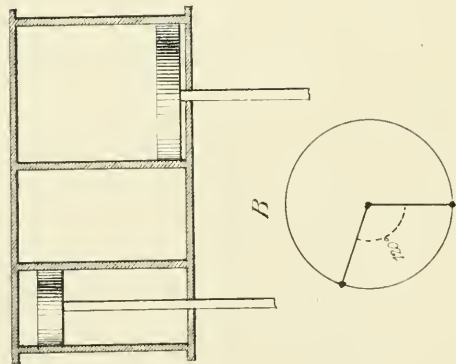


Fig 3 A

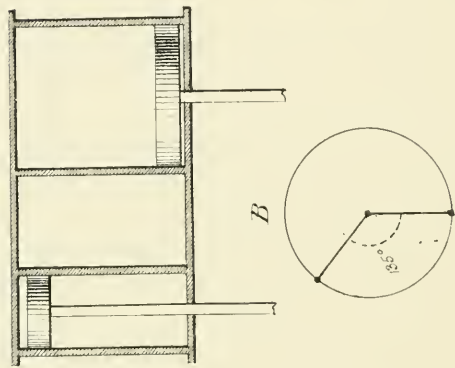
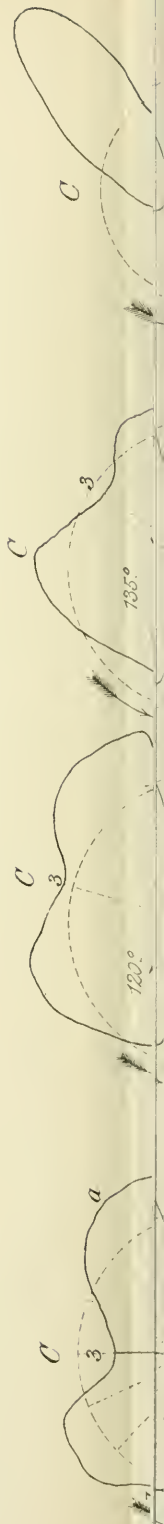
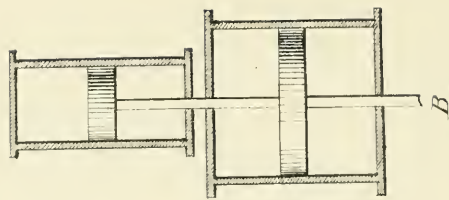
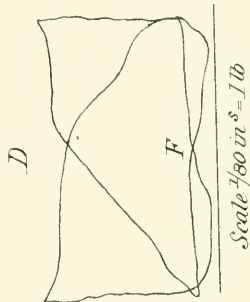
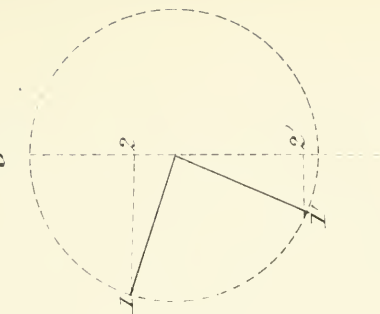
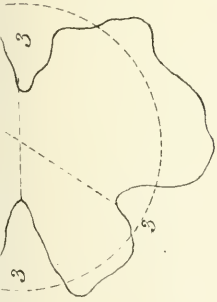
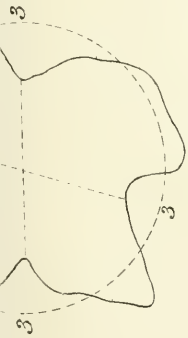
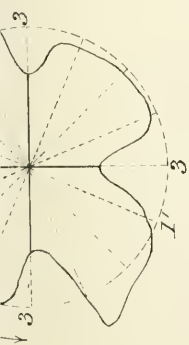
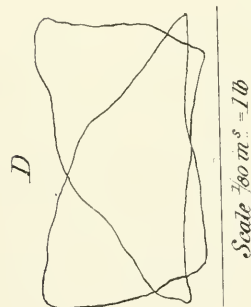


Fig. 4. A

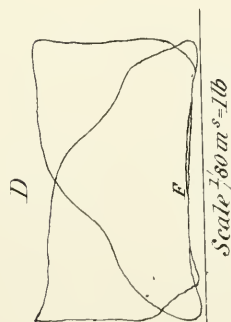




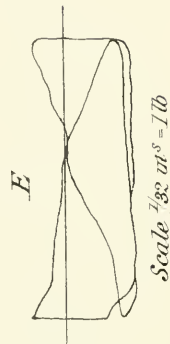
Scale $\frac{7}{80}$ in $s = 1$ lb



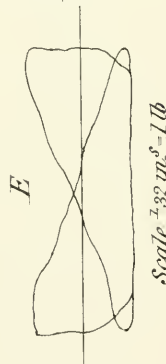
Scale $\frac{7}{80} \text{ in.} = 1 \text{ lb}$



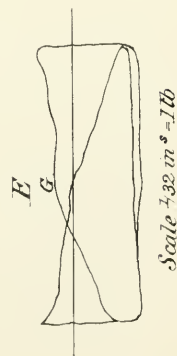
Scale $\frac{1}{80} m^s = 1 lb$



Scale $^{1/32}$ in. = 1 lb



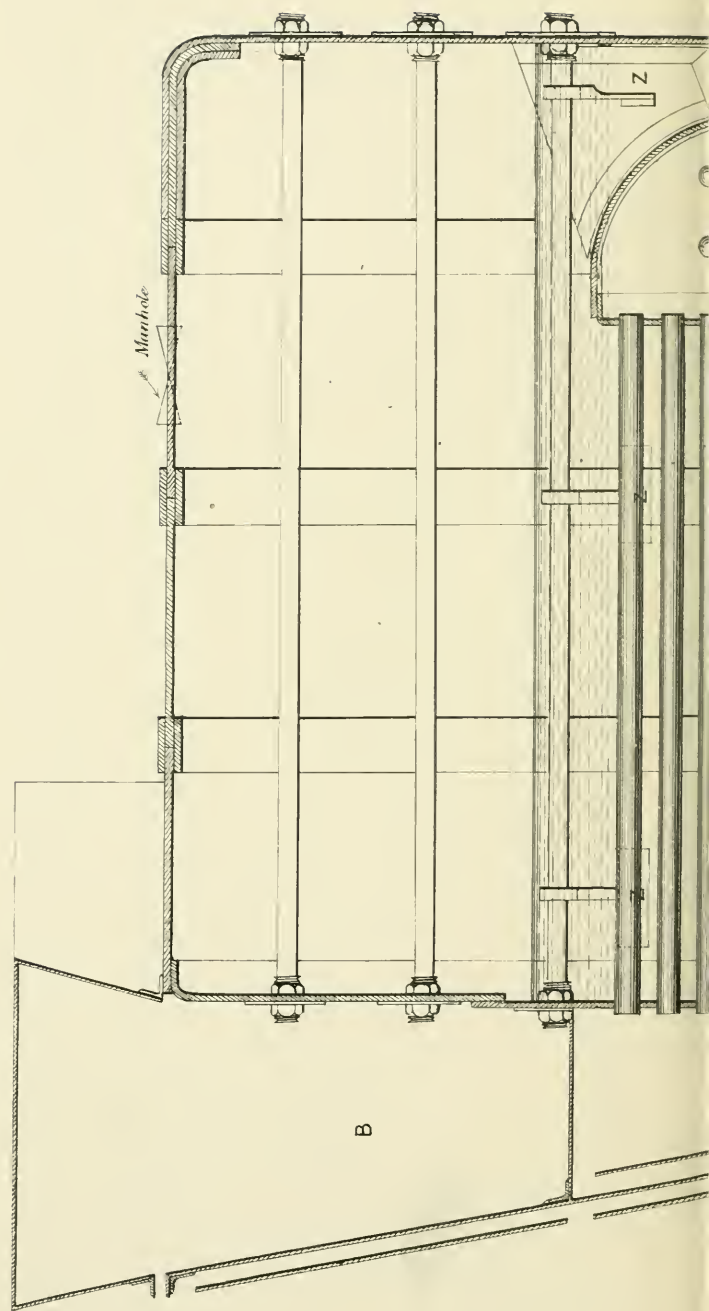
Scale $1:32 m.s = 1 lb$

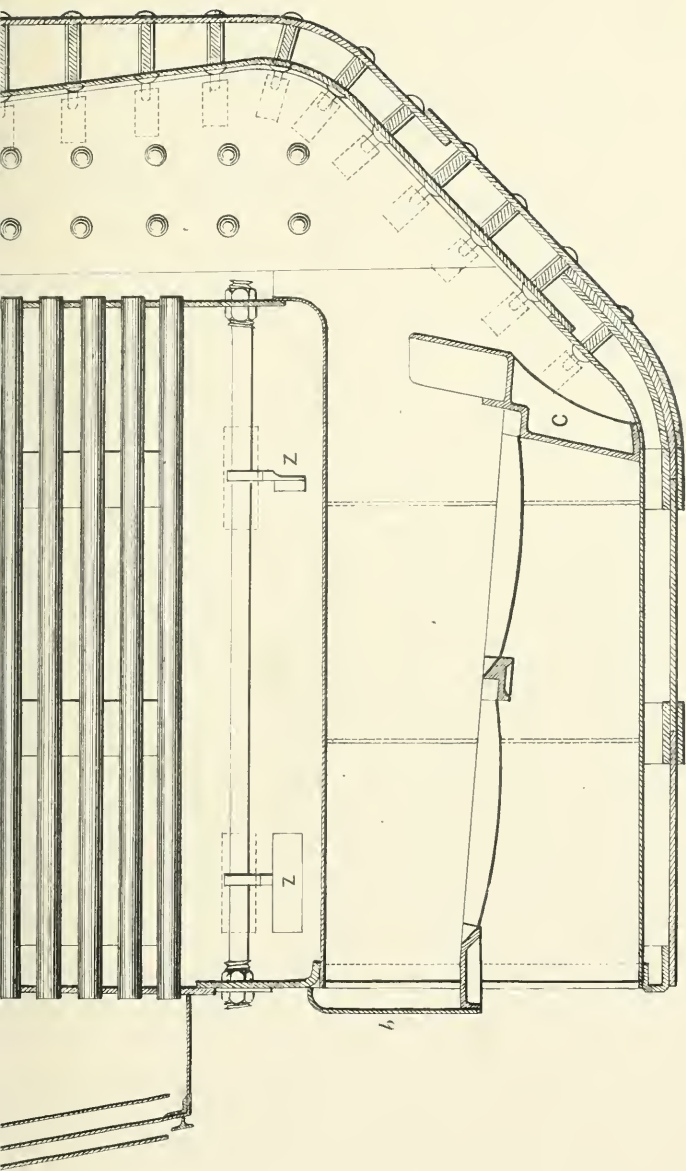


Scale $1/32$ in $s = 1$ lb

To illustrate Mr. Theo. Wood Burnings's paper on the "Marine Engine."

SECTION OF BOILER, LOOKING ON SIDE.





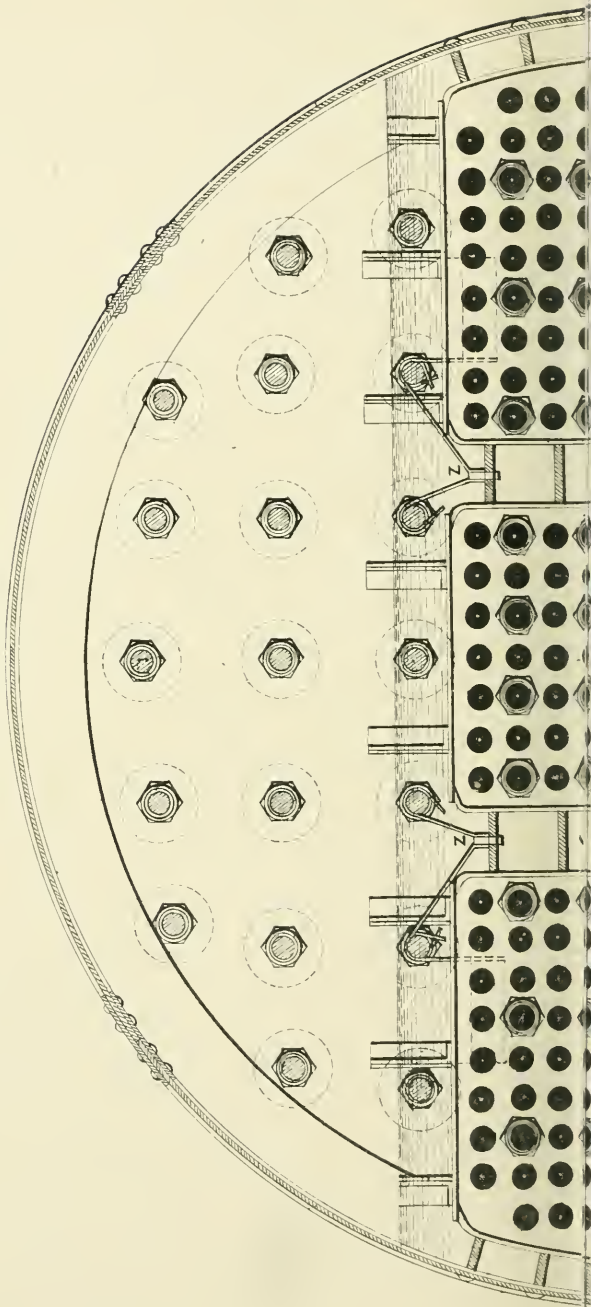
Scale $\frac{1}{2}$ inch = 1 foot.

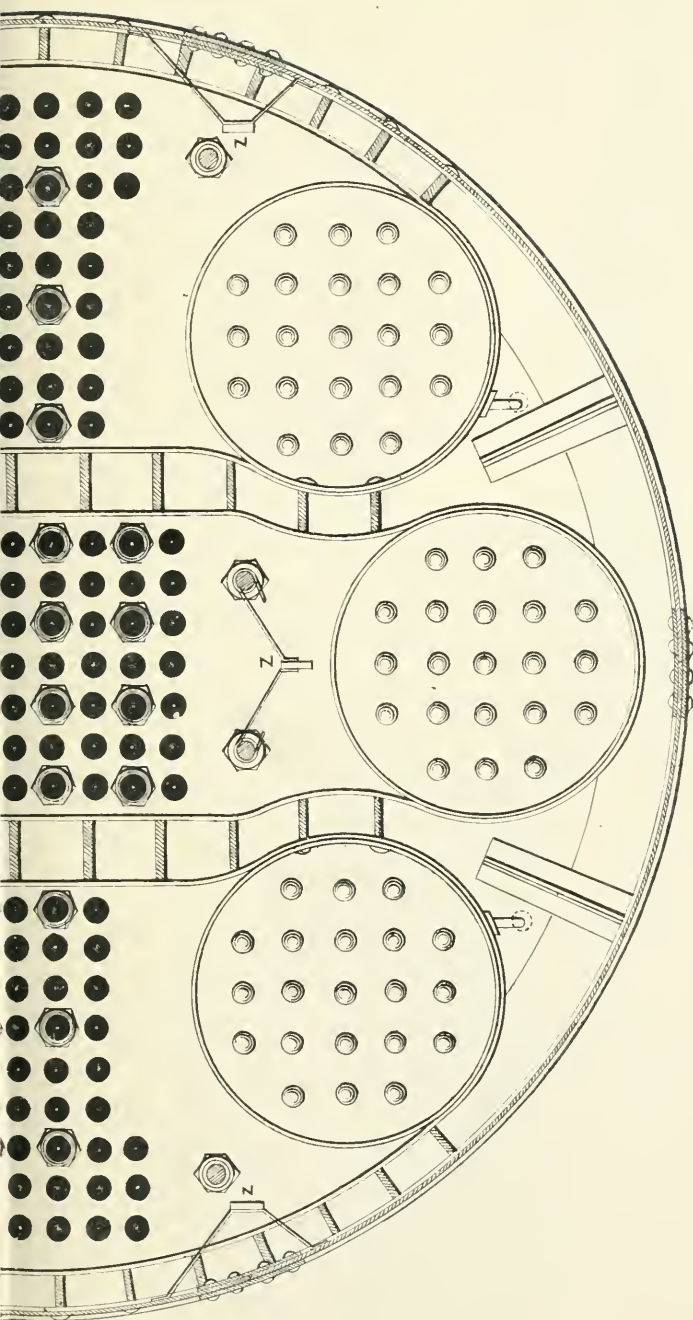
Presented by N. E. I. to M. E. M. E. 1894

Arch. 10. 1894. 1894.

To illustrate Mr. Theo. Wood Bunnings' paper on the "Marine Engine."

SECTION OF BOILER, LOOKING ON FRONT.



Scale $\frac{1}{2}$ inch = foot.

Wormed leaf

Andnd Reid New style



To illustrate Mr Theo Wood Bunnings paper on the "Marine Engine"

FIG. 1.

High Pressure Scale of lbs. $\frac{1}{32}$ to 1 lb

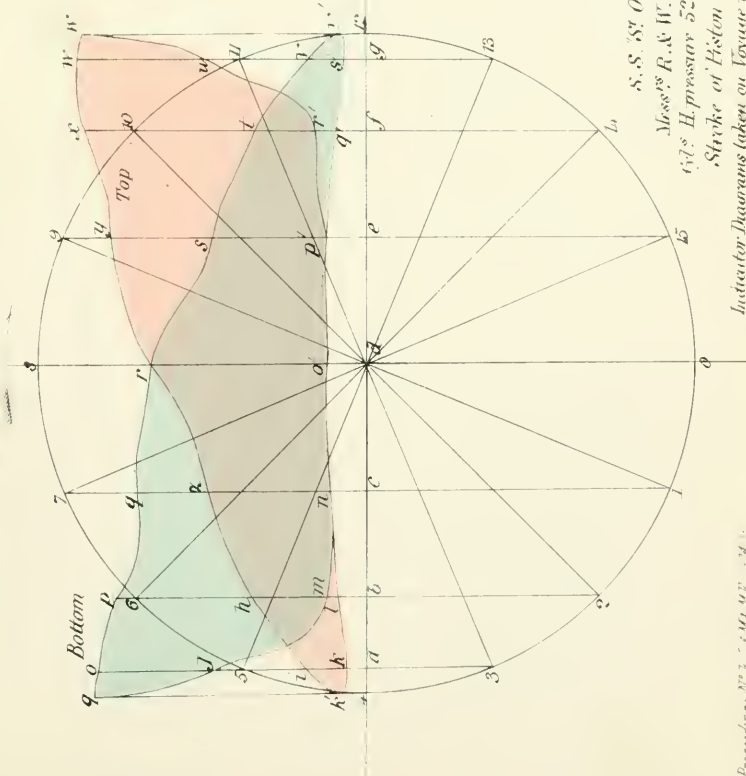
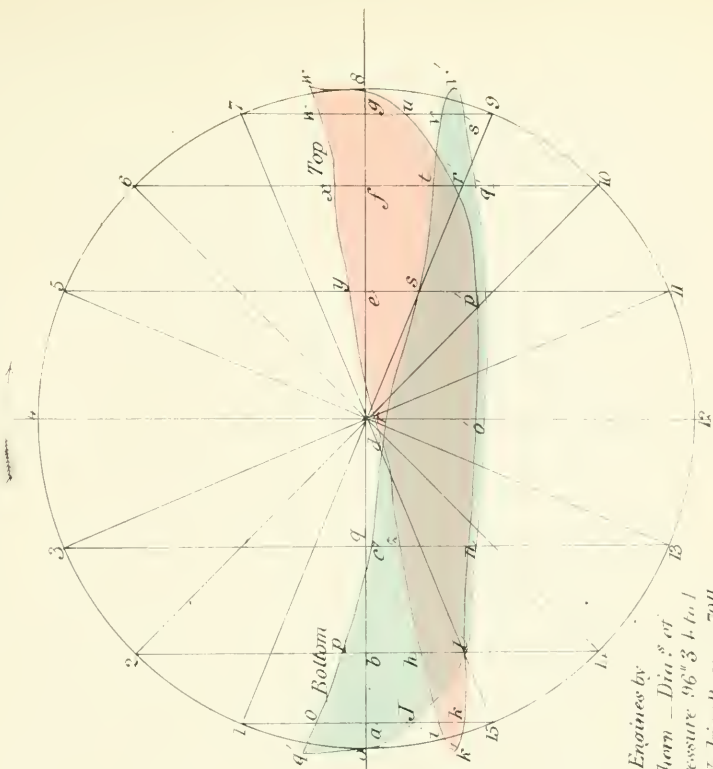


FIG. 2

Low Pressure Scale of lbs. $\frac{1}{16}$ to 1 lb



S. S. S. Ogdth Engines by
Messrs R. & W. Hawthorn — Dia. 5 of
51.5 H. pressure 52.5 L. pressure 96.5 3 4 to 1
Stroke of Piston 51. Working Pressure 70 lbs.

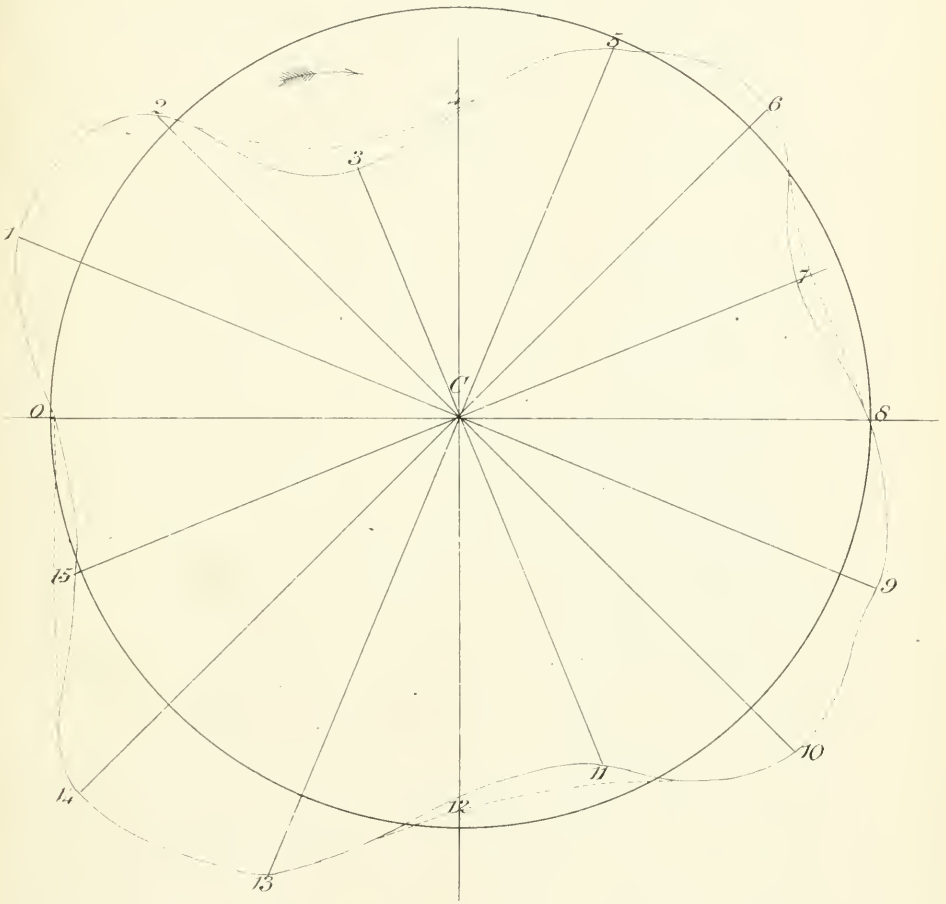
Indicator Diagrams taken on Voyage to Melbourne. 14th November 1874.
Steam 65 lbs. Vacuum 26. Rev. 5 48 — Link Stuns in — Low pres. 6 1/2 "audino

Proceeding: N.E. 1/2 46 43 44

To illustrate Mr Theo. Wood Bunnings's paper on the "Marine Engine".

CRANK EFFORT DIAGRAM.

Scale $\frac{1}{36}^{\text{th}}$ - 1 foot lb.



S.S. "Osyth" Engines by Messrs R & W Hawthorn

Dia^s of Cyl^s 11 pressure 52" L. pressure 96" or 3/4 to 1

Stroke of Piston 51 - Working Pressure 70 lbs

Indicator Diagrams taken on Voyage to Melbourne. 14th November 1874

Steam 65 lbs - Vac^m 26 Revs 48 Link 5 turns in.

Low pressure Cylinder leading

Mr. SIMPSON—But that would require the brakesman to have some particular handle to do it.

Mr. BUNNING—Certainly it would ; but the handle would require only one simple movement, which could be instantaneously given to it, for it would only be required to put steam once either above or below the large piston to put it into rapid motion, and there would then be at the command of the brakesman three or four times the power the engine usually exerted.

Mr. WILLIAM BOYD hoped it would be understood that the discussion of this paper was not to be allowed to drop, for he thought it was too interesting to close there.

A vote of thanks to Mr. Bunning for his paper was moved by Mr. A. Potter, and seconded by Mr. Simpson, and unanimously carried.

Mr. BUNNING thanked them for their very great kindness in passing a vote of thanks to him. He could not but express his pleasure in seeing so many who were old friends long before he joined that Institute ; and he thanked them most cordially for coming to hear him describe what they were so well acquainted with. He trusted that this attempt of his would induce other mechanical engineers to write papers on mechanical subjects. It was a most happy idea, having mechanical and mining members interchanging their ideas, for a mining engineer should know something of mechanical engineering ; and, on the other hand, now when fuel was of the utmost importance, a knowledge of mining was of the utmost value to the mechanical engineer, because if fuel failed he could not sell his wares. He was dependant upon his coal for the use of his boiler, and therefore he, to a certain extent, was interested in the welfare of mining apart from his connection with the Institute. Not only was he interested indirectly, but he was interested directly, because he was called upon in the great development of the mining interest in this country to introduce machinery for all classes of work ; and the deeper the pits became, and the more difficult coal was to get, the more would his brain be taxed to find new ways and new modes of getting coals from greater depths. Therefore, he had always considered that the two professions should go together—that one was necessary to the other—and that by introducing the mechanical element into that Institute they were really doing a great good to all concerned ; and the more the mechanical element developed itself, the more pleased, he was sure, would the mining members of that Institute be ; and he only trusted that some arrangement might be made with the students of mechanical engineering so that a large number of them would join the Institute, and still further extend the mechanical element therein.



APPARATUS FOR EXPLORING IN THE PRESENCE OF
DANGEROUS GASES.

DENAYROUZE'S SYSTEM.

MR. APPLGARTH attended the meeting for the purpose of showing the members how dangerous gases could be penetrated by men protected by an apparatus, the invention of the brothers Denayrouze.

The apparatus, which is in some respects similar to that invented by Mr. T. Y. Hall, and described in Vol. II. of the Proceedings, p. 87, is constructed in three ways to meet three classes of emergencies.

1. To enable a man to enter a room or space that is not far from pure air; this consists simply of an India-rubber tube some 50 feet long, attached to a mouth-piece fixed to the mouth of the operator, the other end remaining in the pure air; the eyes being protected by glasses affixed to a mask partly covering the face, padded with inflated rubber, so as to adjust itself to all the inequalities of the face and remain perfectly air-tight round the eyes, and at the same time clip the nose. The air after having passed through the lungs of the operator, is forced out through a valve which prevents foul air finding its way to the mouth after the expiration is effected.

2. When the distance from the fresh air is too great to enable the operator to draw the air through the tube by his lungs, a pump is added which forces the air to him. This necessitates the use of an apparatus which the operator carries on his back, and which is very ingeniously constructed so as to regulate the pressure at which the air is supplied to the lungs.

3. When the operator has to explore mines at great distances from the pit mouth, and when continuous work has to be done where it is impossible to get a pump applied, highly compressed air is taken down the pit in portable steel reservoirs, and supplied to the regulating apparatus which forms the distinguishing feature of the second mode described.

It being impossible to describe those portions of the apparatus (such

as the regulator, the pump, and the reservoirs,) which constitute its chief merit, without being able to give detailed drawings, it has been considered desirable to delay any further notice of the invention till such perfect drawings can be obtained.

Mr. Applegarth, in the presence of the members, descended into a cellar connected with the Institute, filled with noxious gas, in company with one of the firemen of the town, provided with No. 2 apparatus, and they remained there some time without inconvenience.

The meeting then terminated.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, APRIL 3, 1875, IN THE WOOD
MEMORIAL HALL.

E. F. BOYD, Esq., VICE-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last general meeting, and reported the proceedings of the Council.

The following gentlemen were then elected :—

MEMBERS—

Mr. J. J. REYNOLDS, M.E., Leigh Road, Atherton, near Manchester.
Mr. GEORGE SOUTHERN, 17, Wentworth Place, Newcastle-upon-Tyne.
Mr. MATTHEW RICHARDSON, Jun., West Stanley Colliery, Chester-le-Street.
Mr. JOHN SIMPSON, West Stanley Colliery, Chester-le-Street.

The following were nominated for election at the next meeting :—

MEMBERS—

Mr. THOMAS RUTTER, Blaydon Main Colliery, Blaydon-on-Tyne.
Mr. J. D. WARDALE, Redheugh Engine Works, Gateshead.
Mr. MARTIN HALLIDAY, Peases' West Collieries, Crook.

STUDENTS—

Mr. FRANK DORMAN, Stanley Colliery, Crook.
Mr. J. J. PREST, Belmangate, Guisbro'.
Mr. ROBERT J. HARRISON, Silksworth Colliery, Sunderland.
Mr. THOS. E. CANDLER, East Lodge, Crook.

Mr. G. A. LEBOUR, F.G.S., read the following paper :—



ON THE "GREAT" AND "FOUR-FATHOM" LIMESTONES
AND THEIR ASSOCIATED BEDS IN SOUTH NORTHUM-
BERLAND.

 BY G. A. LEBOUR, F.G.S. LOND. AND BELG., F.R.G.S., ETC.

THIS paper must be looked upon as a continuation, to a certain extent, of that of the author on the "Little Limestone,"* recently read by him here. The geographical area treated of is the same in both, viz. :—the district between the South Tyne and the Tyne proper on the south, and the Wansbeck on the north. In the last paper, however, the breadth of the area was somewhat considerable, as it comprised the whole of the country formed by the outcrop of some 1,500 feet or more of strata, dipping at a low angle. In the present case, the thickness is very much less, and the dip is as a rule greater, so that the region to be described is a very narrow one, a mere strip of country, in fact, which may be roughly said to extend from Haltwhistle to the west to Elf Hills on the Wansbeck Valley line to the north-east, and the lines of trend of which may be broadly looked upon as making an obtuse angle, the apex of which is at Great Whittington, near Matfen. Although many of the names of localities mentioned throughout this paper are necessarily the same as those referred to in the "Little Limestone" paper, yet there will not be any real repetition since the beds treated of now are all below those previously described, although they are contiguous to them. By taking the limestone series as he is doing, bed by bed, the writer is actuated by the conviction that this mode is the best for classifying clearly the local details, on the proper arrangement of which the value of such papers depends.

Beginning immediately below the bottom seam of the "Little Limestone" coal, in the Alston section, according to Westgarth Forster, we have the following beds in descending order,† the thicknesses being given in feet :—

* Trans. N. of England Inst. Min. Engineers, Vol. XXIV., p. 73.

† "A Treatise on a Section of the Strata," etc., by Westgarth Forster, 1821, p. 167.

									Ft.	In.
1.—Low Coal Sill ...	...	...	...	...	...	...	...	...	10	0
2.—Plate ...	...	...	...	...	...	...	...	...	18	0
4.—Third Tumbler Beds, Black Bed, and Great Limestone ...	...	...	...	...	...	...	...	...	63	0
5.—Tuft or Water Sill ...	...	...	...	...	...	...	...	...	9	0
6.—Plate ...	...	...	...	...	...	...	...	...	21	0
7.—Small Limestone ...	...	...	...	...	...	...	...	...	1	6
8.—Quarry Hazle ...	...	...	...	...	...	...	...	...	30	0
9.—Plate ...	...	...	...	...	...	...	...	...	33	0
10.—Till Bed ...	...	...	...	...	...	...	...	...	7	6
11.—Four-Fathom Limestone ...	...	...	...	...	...	...	...	...	24	0
12.—Nattriss Gill Hazle ...	...	...	...	...	...	...	...	...	18	0
13.—Plate ...	...	...	...	...	...	...	...	...	33	0
14.—Three Yards Limestone ...	...	...	...	...	...	...	...	...	9	0
Total ...	...	...	...	...	...	...	...	...	277	0

It is the range and changes of these beds within the boundaries mentioned, which it is the object of this paper to describe. The Three-Yard Limestone, however, is only referred to here so as to give a tangible base to the series under consideration ; it will not be described at present.

In many respects, the beds included in the above section are among the most important of the Carboniferous Limestone series in Northumberland, for building, agricultural, and mining purposes. They comprise two of the best building stones, two of the best limestones, both for burning and for road-making, and at least one thick bed of shale, with black band and nodular clay ironstone. The two limestones are the best known of the series in the lead districts, and Westgarth Forster's description of them may properly be given here. He says of the "Great Limestone,"* "This is the most predominant stratum of limestone that we find throughout the whole section, and has been nearly as productive of lead ore as all the other strata taken together, in the extensive mines of *Weardale* and *Teesdale* in the county of Durham, *East* and *West Allendales* in the county of Northumberland, and *Alston Moor* and *Cross Fell* in the county of Cumberland. About sixteen feet of the upper part of this stratum is called the *Tumbler Beds*, which, in some places, contain entroche and other organic remains. Between the Tumbler Beds and body of the limestone, is a soft argillaceous substance, about a foot thick, commonly called the Black Bed."

Of the "Four-Fathom Limestone" he says, "This is a strong close stratum of limestone, keeping pretty regular in its thickness wherever it has been sunk through." A little further on, he adds, "It may be

* Op. Cit., p. 102.

observed that limestones in general are more regular in their thickness than any other stratum throughout this [*his*] section.”*

Mr. Sopwith, in his excellent little book on the mining districts,† confirms all that Forster says respecting these two beds, adopts his section, and adds some interesting information as to the mining peculiarities of each stratum.

Both these authorities, however, describe the series as it is known at Alston and at Allenheads, and no attempt has, to the author's knowledge, been made to follow the changes undergone by it in its extension to the north and east, except that of Mr. T. J. Bewick, the results of which take the form of horizontal sections of great interest to local geologists, showing very clearly the author's view as to the arrangement of the beds in question at four different points between Haltwhistle and Fourstones, in South Tynedale.‡

All the beds under consideration can be well seen in the upper part of the Haltwhistle Burn, near the military road; the general dip is here rather high (8° or 10°), and is southerly in its direction. At Low Fogrigg, according to Mr. Bewick's plate, the section is as follows (the thicknesses being approximative only):—

	Ft.	In.
1.—Beds between the “Little” and “Great Limestones” ...	50	0
2.—“Great Limestone”	38	0
3.—Quarry Hazle	77	0
4.—“Four-Fathom Limestone”	20	0
5.—Sandstone	15	0
6.—Shale	25	0
7.—Sandstone	55	0
Limestone (“Scar Limestone” of Mr. Bewick) Total ...	280	0

This section is doubtless a little generalized, but still it is a very good typical one of the series north of the Tyne. The changes which are seen to have occurred in the passage of the beds from Alston to Haltwhistle are—First, a marked thinning of the “Great Limestone” from 63 to 38 feet, and the total disappearance of the Tumbler Beds and Black Bed as such. These Tumbler Beds consist of thin beds of rubbly impure limestone, divided by “famp” beds, or earthy shales. They are very characteristic of the “Great Limestone” in the Alston district, and the black bed, a band of very unctuous earthy shale, is also very well known there. North

* Op. Cit., p. 105.

† “An Account of the Mining Districts of Alston Moor, Weardale, and Teesdale,” etc., by T. Sopwith, Alnwick, 1833, p. 90, etc.

‡ Trans. N. of England Inst. Mining Engineers, Vol. XVIII., Plates 42, 43, 44.

of Tyne, however, this portion of the "Great Limestone" is always absent, but whether it has thinned out altogether, or whether it be represented by the upper "posts" or layers of the main limestone, there is no evidence to show. Either of these contingencies is possible. This change has been the cause of some errors in the identification of the beds, some miners, accustomed to the constant presence of the "Tumblers," having taken the "Great Limestone" itself for them, and imagined the "Four-Fathom Limestone" to be the "Great"—the thin black bed being, as they thought, represented by the 70 or 80 feet of sandstone to be found here between the two. The confusion thus arrived at can be imagined. The so-called "Tuft or Water Sill" of the Alston section is not recognisable as a separate bed here; the shale below it is, however, represented by a series of "grey beds" (alternating thin shales and sandstones) which pass below into the thick sandstone known as the Quarry Hazle, under which name the whole is included in Mr. Bewick's sections. The very thin "limestone post" of the Alston section, which is, notwithstanding its thinness (about 18 inches), unpleasantly familiar to miners in that district, where "in sinking through it great inconvenience is often found from the quantity of water in it,"* is fortunately also absent to the north. The Quarry Hazle, which in the Alston district varies from 12 to 30 feet, is considerably thicker here, and the "plate" or shale bed which is usually found immediately underlying it seems, according to Mr. Bewick, to be absent, although it soon reappears. No. 10 of Forster's section, the "Till Bed," is a curious bed of astonishing constancy. In places it is a cherty, brownish-black shale in structure, but with exactly the facies of an altered bed. It is, of all the beds known to the writer in Northumberland, that which most closely resembles the beds of "Phthanite" or "Kieselschiefer," which play so important a part in the Carboniferous rocks of the Continent. This bed is too thin to be recorded in Mr. Bewick's section, but it is no doubt present at Fogrigg, since the writer has nowhere yet found the "Four-Fathom Limestone" without this overlying bed. It is remarkable that in places this silicious band is remarkable for the quantity of fossils it contains, being, in fact, the most prominent trilobite bed in the series. The "Four-Fathom Limestone" itself is here much about the same thickness as at Alston, perhaps a little thinner; but, as will be seen presently, it soon thickens again for a space to the east. Nos. 12 and 13 of the Alston section are both somewhat thinner here, but are clearly to be distinguished and followed on the surface. The beds below this do not come within the scope of this paper.

* Sopwith, *Op. Cit.*, p. 91.

From the foregoing statements it will be seen that, beyond the disappearance of the "Tumbler Beds," no great change has taken place in this set of beds from Alston to Fogrigg—that is, from south to north, a distance of about twenty miles.

A little to the east of Fogrigg and to the south of Sewingshields, Mr. Bewick's sections show the following alterations:—The beds between the "Little" and "Great Limestones" have more than trebled in thickness, being here 170 feet. The "Great Limestone" has thinned slightly from 38 to 30 feet. The "Quarry Hazle" (which it will be more convenient north of Tyne to call by its local name of the "Prudham Stone," by which it is well known as a building stone) is of exactly the same thickness; but the shale below it, which was absent at Fogrigg, puts in an appearance, being here about 12 feet thick. The "Four-Fathom Limestone" has thickened a little, being now 25 feet thick, the beds below it remaining much the same as before.

Proceeding eastwards, the hitherto regular outcrops of the beds become disrupted for some distance between Grindon Hill and Newbrough by the system of faults which forms the well-known mining district of Stonecroft and Settlingstones. To describe the direction and throw of these numerous faults and veins would entail an elaborate discussion of the dislocations of the district, besides treading on disputed ground which would have no direct connexion with the subject of this paper. This area had, therefore, better be passed over with a few necessary notes only. All the north-east and south-west faults of this region affect the outcrops of the beds under consideration, the effects of the throws being heightened by the form of the ground, which, being generally a rapid slope to the South Tyne, at an angle not very dissimilar from that of the dip, causes the exposed edges of the beds to cover a much greater area than would otherwise be the case; thus, at Lipwood there is a great spread formed by "Four-Fathom Limestone," which is here about 40 feet thick, while both that and the "Great Limestone" give rise to similar spreads at several places to the north of Haydon Bridge. The various faults (or at least the more important ones) and their effects will be found laid down in the maps of the Geological Survey. It is probable that to some extent the great thickening of the "Four-Fathom Limestone" at Lipwood is due to the rolling of that bed in close proximity, as it is, to a fault of some magnitude. Rolling is by no means an ordinary characteristic of this limestone, whereas it is very marked in the "Great Limestone." (See Fig. 2, Plate XXXII.). This fact, and the increased thickness, have no doubt contributed to the belief held by some that the Lipwood

limestone is really the "Great Limestone." The stratigraphical relations of this bed, however, and its fossil character, which will be adverted to presently, can leave no doubt as to the propriety of identifying it as the "Four-Fathom."

The faulted area referred to is at an end at Allerwash, on the South Tyne, and thence to the northern limit of the region under consideration, none but unimportant breaks interrupt the continuity of the outcrops of the beds in question.

The thicknesses, as far as the limestones are concerned, are not from this point subject to great variations: the "Four-Fathom Limestone" has resumed its accustomed appearance and thickness, being between 20 and 30 feet.

A little lower down the river the "Great Limestone" is very well seen, dipping into its bed and turning thence inland towards the great Four-stones Quarries, which afford perhaps the best section of the entire series. The limestone is here extensively worked, and a considerable thickness of the black shale above it is bared in the quarrying operations, while below it is the great Prudham Stone Quarry, and below that again the "Four-Fathom Limestone" is worked on a small scale and well exposed in a small quarry in the south-east corner of the Newbrough grounds. (See Fig. 1, Plate XXXII.)

The rocks are here free from drift, and having a dip of about 10° decreasing towards the east, are very easily traced to the North Tyne, which they cross about Walwick Grange, the "Great Limestone" being marked by small workings almost all along its course. From this point to Brunton, where the "Great Limestone" is again extensively quarried, the outcrops are again quite clear. At the latter place, the sandstone lying above the "Great Limestone" shale (the "hazle" of the Fallowfield section) is quarried under the name of the "Black-Pasture Stone." This bed is here a good strong building stone, nearly as thick as the Prudham Stone; and from the evidence afforded by the Fallowfield shafts, it appears to continue massive and thick some distance to the south; to the east and west, however, it breaks up into a series of thin sandstones of various qualities interbedded with micaceous shales, making, in fact, a set of "grey beds." This is a good instance of the inconstancy of some of the more marked sandstones of the Carboniferous Limestone series, which is so usual in the north-western part of Northumberland, but which is comparatively rare in its southern portion.

Continuing to the east as far as Grottingham, close to the Watling Street, the line of our beds is unbroken save by the St. Oswald's Whin

Dyke, which being a filled-up fault, throws them about fifty feet ; beds and dyke being both beautifully exposed on the long hill side, which forms the southern flank of the Erring Burn valley. At Grottingham, however, a somewhat puzzling stratigraphical arrangement of the beds obtains. There (see Fig. 3, Plate XXXII.) the "Great Limestone" curves to meet the north-easterly continuation of the great Fallowfield fault and vein, and is cut off by it, whereas, the "Four-Fathom Limestone" and the lower beds hold on their parallel but lower course without interruption. The explanation of this apparently anomalous state of things is that a small east and west fault running just to the south of Bewclay meets and stops the Fallowfield vein, and having an inconsiderable downthrow to the south, leaves a kind of denuded peninsula of "Great Limestone" (B in the sketch) which at first sight seems to be unconnected with the western main-mass. Another small fault associated with the last, but having a downthrow in the opposite direction, nearly doubles the apparent thickness of the "Great Limestone" at Bewclay, which is, however, not really above 30 feet thick.

A little beyond Bewclay, to the east, the great elbow or bend to which all the beds of the district are subject, causes the strike to alter from nearly east and west, to nearly north and south, and for some miles, as far as the Wansbeck indeed, their trend is perfectly regular. The greatest heights are here formed by the "Great Limestone" which, with dip-slopes to the east, forms a series of fan-shaped expanses on the map, the apices of which face the west. A steep crag face of Prudham stone below brings one to a ledge of "Four-Fathom Limestone," and a similar slope, including the "Natriss Gill Hazle" to the next limestone below it. This arrangement is well shown at Mootlaw, Kirkheaton, and Ryall, along the line of baset. Near the road from Bavington to Capheaton, the Bavington or Bolam Whin Dyke runs through the beds in a north-east and south-west direction, and faults them, but only very slightly.

Close to the Wansbeck edge a somewhat greater fault, running nearly east and west, throws the beds down to the north, but again only to a small extent. About a mile north of this point, however, a new element of disturbance comes into play, namely, the intrusion of two masses of basalt at Broom House and Elf Hills, which are, as it were, the easternmost off-shoots of the eastern branch of the great Whin Sill.

The Broom House mass comes up through the outcrop of the "Great Limestone," bursting through it and tossing it suddenly at a high angle on its northern flank, and causing a high dip, which is, however, only observable near to the whin, and soon diminishes to the north.

At Elf Hills, it is the "Four-Fathom Limestone" which is affected

by the whin. Here both the limestone and the whin are quarried, and beautiful and most instructive sections have been thus from time to time exposed, which have fortunately—Sir Walter C. Trevelyan being their proprietor—not been allowed to disappear unobserved. The basalt has here divided itself into sheets running through the limestone, not only parallel to the bedding, but also upwards along lines of joints and fissures into the limestone. The sections showing this arrangement have been described by Mr. W. Topley, F.G.S., and the writer, in a joint paper read in 1873, at the Bradford meeting of the British Association, of which unfortunately an abstract only has yet been published, but which, it is hoped, will soon be issued in an extended form.* These sections, of one of which a diagrammatic sketch is given (see Fig. 1, Plate XXXIII.) can, the writer believes, leave no doubt whatever as to the fact, which was formerly hotly contested by Hutton and others against the late Prof. Sedgwick, that the Whin Sill is most certainly a purely intrusive and non-contemporaneous sheet of basaltic trap. This Elf Hills section alone would prove it, were its evidence not confirmed by the study of the Whin Sill at almost every point of its course in Northumberland. This fact is a good example of the small value attaching to merely local observations of a *negative* character in geology, since *out* of Northumberland, an examination of a great portion of the course of the Great Whin Sill might lead (as it has led) to exactly opposite conclusions.

Returning from this necessary digression, to the beds under consideration, the writer would especially note that at some points of their course within the district between Tyne and Wansbeck, thin local seams of coal occur; as, for instance, at Great Whittington, where immediately below the “Great Limestone” the section is as follows:—

								Ft.	In.
1.—Great Limestone									
2.—Dark brown shale	...	...	...	...	...	about	2	0	
3.—Coal	...	...	...	...	...	...	0	4	
4.—Band	...	...	...	...	...	about	1	0	
5.—Slaty coal	...	...	...	...	...	...	0	10	
6.—Sandstone	...	...	...	...	...	about	15	0	
7.—Shale	...	...	...	...	...	about	10	0	
8.—Coal	...	...	...	...	...	1 ft. to 2	4		
9.—Shale	...	...	...	...	...	10 ft. to 1	0		
10.—Prudham stone									

The appearance of these limited seams, which borings have proved to be of bad quality and small area, is occasionally a stumbling-block to miners

* See Reports Brit. Ass., 1873, p. 92.

in this district, since they are apt to be mistaken for the really workable "Little Limestone" coal above.

In the "plate" or shale underlying the "Natriss Gill Hazle," is a thin black band which has been from time to time worked in the southern part of this district; and also a very irregular (so far as quality is concerned) deposit of ironstone nodules, which has also been wrought along the outcrop of the shale from Haltwhistle Burn to Chesterholm, but not very profitably. This shale is geologically the same as the Brinkburn ironstone shale in the northern half of the county.

With regard to the identification of the beds here described with those in the northern parts of the county, the writer will not hazard an opinion at present. The labours of Mr. Topley in that district have already thrown much light on this subject, and the true relation of the beds will not fail, sooner or later, to be known. At present all that need be said is that the Ebb's Nook Limestone of the Alnwick district, is certainly the same as our "Great Limestone."

As a contribution to the work of identification, the writer adds a list of the fossils hitherto found in the "Great" and "Four-Fathom" limestone, which he has compiled from every available source, including his own collections, and the late Mr. George Tate's lists.

In this long list,* only *one* can be fairly called a characteristic fossil. That is the small organism now known as *Saccammina Carteri*, a foraminifer, which was found a few years ago for the first time, by Sir W. Trevelyan, in the "Four-Fathom Limestone" at Elf Hills, and described by H. B. Brady, F.R.S.† Since that time, wherever this limestone has been searched in Northumberland, this organism has been found forming either one or two regular "posts" or beds within it, chiefly towards its base: in this county, therefore, it is a very valuable help towards the identification of the "Four-Fathom Limestone," for it has never yet been found in any other bed here. In Durham, Mr. Howse has discovered it in the "Great Limestone," but not in any mass or number. In Scotland and in Yorkshire, it has also been found since its discovery in Northumberland, but the exact relative horizon of the beds containing it is not known yet. A lithograph of the *Saccammina* is appended to the present memoir. Although new to science, it has long been known to the Alston Moor miners, who have for years called the bed containing it, the "spotted post." (Fig. 2, Plate XXXIII.)

* Long as it is, it is the result of very desultory collecting, and a systematic search in these beds, would doubtless reveal a much larger number of species.

† See Annals and Magazine of Natural History, Ser. 4, Vol. 13, p. xii.

LIST OF FOSSILS FOUND IN THE "GREAT" AND "FOUR FATHOM"
LIMESTONES.

The stars denote the presence of the fossils in the strata under which they stand.

						Great Limestone.	Four Fathom Limestone.
Saccammina Carteri.	Brady	...	...	...	...	—	*
Trochammina incerta.	D'Orb.	...	...	...	...	*	*
Tr. gordialis.	P. & J.	...	...	...	...	—	*
Tr. annularis.	Brady	...	...	...	...	...	*
Textularia (?)	...	...	...	...	...	—	*
Chaetetes tumidus.	Phill.	...	...	...	...	*	*
Aulophyllum prolapsum.	McCoy	...	...	...	...	*	*
Cladochonus bacillaris.	McCoy	...	...	...	...	—	*
Favosites parasitica.	Phill.	...	...	...	...	*	*
Lithostrotion irregulare.	Phill.	...	...	...	...	*	—
Griffithides Farnensis.	Tate	...	...	...	...	*	*
Gr. sp.	...	...	...	...	...	—	*
Leperditia sp.	...	...	...	...	...	*	—
Spirorbis carbonarius.	March.	...	...	...	...	*	—
Archæocidaris Urii.	Flem.	...	...	...	...	*	*
Poteriocrinus crassus.	Mill.	...	...	...	...	*	*
Glaucanome pulcherrima.	McCoy	...	...	...	...	*	*
Gl. pluma.	Phill.	...	...	...	...	*	—
Fenestella plebeia.	McCoy	...	...	...	...	*	—
F. membranacea.	Phill.	...	...	...	...	*	—
Lingula mytiloides.	Sow.	...	...	...	...	—	*
L. squamiformis.	Phill.	...	...	...	...	*	*
L. sp.	...	...	...	...	...	—	*
Productus fimbriatus.	Sow.	...	...	...	...	*	*
Pr. punctatus.	Mart.	...	...	...	...	*	*
Pr. scabriculus.	Mart.	...	...	...	...	*	—
Pr. Flemingii.	Sow.	...	...	...	...	*	*
Pr. Martini.	Sow.	...	...	...	...	*	*
Pr. semireticulatus.	Mart.	...	...	...	...	*	*
Pr. Cora.	D'Orb.	...	...	...	...	*	*
Pr. catissimus.	Sow.	...	...	...	...	*	*
Pr. giganteus.	Mart.	...	...	...	...	*	*
Orthis Michelini.	Lec.	...	...	...	...	*	*
Or. resupinata.	Mart.	...	...	...	...	*	*
Streptorhynchus crenistria.	Phill.	...	...	...	...	*	*
S. arachnoidea.	Phill.	...	...	...	...	*	—
Rhynchonella pleurodon?	Phill.	...	...	...	...	*	*
Spiriferina Caminosa	...	...	...	...	...	*	—
Sp. octoplicata.	Sow.	...	...	...	...	*	...
Spirifer pinguis.	Sow.	...	...	...	...	—	*

						Great Limestone.	Four Fathom Limestone.
Sp. lineatus.	Mart.	...	...	...	...	*	*
Sp. Urii.	Flem.	...	...	...	...	*	—
Sp. glaber.	Mart.	...	...	...	...	*	*
Sp. sex-radialis.	Phill.	...	...	...	...	*	—
Sp. bisulcatus.	Sow.	...	...	...	...	*	*
Sp. trigonalis.	Mart.	...	...	...	...	*	*
Athyris ambigua.	Sow.	...	...	...	...	—	*
A. plano-sulcata.	Phill.	...	...	...	...	—	*
Astarte tremula.	De Ryck.	...	...	...	...	—	*
Solemya primæva.	Phill.	...	...	...	...	*	*
Arca cancellata.	Mart.	...	...	...	...	*	*
Leda attenuata.	Flem.	...	...	...	...	*	*
Ctenodonta undulata.	Phill.	...	...	...	...	—	*
Ct. gibbosa.	Flem.	...	...	...	...	*	*
Leptodomus costellatus.	McCoy.	...	...	...	...	*	—
Sanguinolites striato-lamellosus.	De Kon.	...	...	...	...	*	—
S. constrictus.	King.	...	...	...	...	*	—
S. angustatus.	Phill.	...	...	...	...	—	*
S. transversus.	Port.	...	...	...	...	*	—
S. tridinoides.	McCoy	...	...	...	...	*	—
S. variabilis.	McCoy	...	...	...	...	*	*
Edmondia rudis.	McCoy	...	...	...	...	—	*
E. sulcata.	Phill.	...	...	...	...	*	*
E. oblonga.	McCoy	...	...	...	...	*	*
Myophoria depressa.	Port.	...	...	...	...	—	*
Lithodomus dactyloides.	McCoy	...	...	...	...	—	*
Pinna membranacea.	De Kon.	...	...	...	...	*	—
P. flexicostata.	McCoy	...	...	...	...	*	—
P. flabelliformis.	Mart.	...	...	...	...	*	—
Aviculopecten variabilis.	McCoy	...	...	...	...	—	*
Av. tabulatus.	McCoy	...	...	...	...	—	*
Av. micropteris.	McCoy	...	...	...	...	—	*
Av. duplicostatus.	McCoy	...	...	...	...	*	—
Av. interstitialis.	Phill.	...	...	...	...	*	*
Av. concentrico-striatus.	McCoy	...	...	...	...	—	*
Av. cancellatus.	McCoy	...	...	...	...	—	*
Av. celatus.	McCoy	...	...	...	...	—	*
Streblopteria pulchella.	McCoy	...	...	...	...	—	*
S. lævigata.	McCoy	...	...	...	...	—	*
Pteronites persulcatus.	McCoy	...	...	...	...	—	*
Amusium deornatum.	Phill.	...	...	...	...	*	*
Am. Sowerbyi.	McCoy	...	...	...	...	*	—
Pecten sub-elongatus.	McCoy	...	...	...	...	*	—
Conularia quadrisulcata.	Sow.	...	...	...	...	*	—
Macrocheilus acutus.	Sow.	...	...	...	...	—	*
M. spiratus.	McCoy	...	...	...	...	*	*
M. ovalis.	McCoy	...	...	...	...	—	*

							Great Limestone.	Four Fathom Limestone
<i>M. sigmilineus</i> , <i>D'Orb.</i>	—	...	*
<i>M. limnaeiformis</i> , <i>McCoy</i>	*	...	—
<i>Loxonema elongata</i> , <i>De Kon.</i>	*	...	—
<i>L. tumida</i> , <i>Phill.</i>	*	...	*
<i>L. rugifera</i> , <i>Phill.</i>	*	...	*
<i>L. sulculosa</i> , <i>Phill.</i>	—	...	*
<i>Naticopsis plicistria</i> , <i>Phill.</i>	*	...	*
<i>N. spirata</i>	—	...	*
<i>Euomphalus tabulatus</i> , <i>Phill.</i>	—	...	*
<i>E. Dionysii</i> , <i>Goldf.</i>	—	...	*
<i>E. costellatus</i> , <i>McCoy</i>	*	...	—
<i>E. carbonarius</i> , <i>Sow.</i>	*	...	*
<i>E. catillus</i> , <i>Mart.</i>	—	...	*
<i>Murchisonia quadricarinata</i> , <i>McCoy</i>	*	...	*
<i>M. angulata</i> ? <i>Phill.</i>	—	...	*
<i>M. sp.</i>	—	...	*
<i>Pleurotomaria monilifera</i> , <i>Phill.</i>	—	...	*
<i>Pl. decipiens</i> , <i>McCoy</i>	*	...	—
<i>Pl. atomaria</i> , <i>Phill.</i>	*	...	—
<i>Capulus trilobatus</i> , <i>Phill.</i>	*	...	*
<i>Bellerophon Urvii</i> , <i>Flem.</i>	*	...	—
<i>B. striatus</i> , <i>Flem.</i>	*	...	—
<i>B. decussatus</i> , <i>Flem.</i>	*	...	*
<i>B. navicula</i> , <i>Sow.</i>	*	...	*
<i>Actinoceras giganteum</i> , <i>Sow.</i>	*	...	*
<i>Poterioceras cornu-vaccinum</i> , <i>McCoy</i>	—	...	*
<i>Orthoceras undulatum</i> , <i>Sow.</i>	*	...	—
<i>O. sulcatum</i> , <i>Flem.</i>	*	...	*
<i>O. attenuatum</i> , <i>Flem.</i>	—	...	*
<i>O. cylindraceum</i> , <i>Flem.</i>	—	...	*
<i>O. inequiseptum</i> , <i>Phill.</i>	*	...	—
<i>O. pyramidale</i> , <i>Flem.</i>	*	...	—
<i>O. Goldfussianum</i> , <i>De Kon.</i>	—	...	*
<i>Nautilus ingens</i> , <i>Mart.</i>	*	...	—
<i>N. globatus</i> , <i>Sow.</i>	*	...	—
<i>N. bilobatus</i> , <i>Sow.</i>	*	...	—
<i>N. costato-coronatus</i> , <i>McCoy</i>	*	...	—
<i>N. subsulcatus</i> , <i>Phill.</i>	*	...	*
<i>N. biangulatus</i> , <i>Sow.</i>	*	...	*
<i>N. sulcatus</i> , <i>Sow.</i>	*	...	*
<i>N. perplanatus</i> , <i>Port.</i>	*	...	*
<i>Psammodus cornutus</i> , <i>Ag.</i>	—	...	*
<i>Rhizodus Hibberti</i> , <i>Ag.</i>	*	...	—

For the Foraminifera which head this list, the author is indebted to his friend H. B. BRADY, F.R.S. It may be here noted that the litho-

graph of *Saccamina Carteri* which accompanies this paper is somewhat lacking in the accuracy of detail which characterized the original drawing—it is, nevertheless, a fair general representation of a piece of the weathered surface of the rock.

The CHAIRMAN said he was sure they would join him in a vote of thanks to Mr. Lebour for the extraordinary pains and labour he must have bestowed upon that paper. He himself had had the honour of reading a paper before the Institute, describing a portion of the district, namely, from Belford to Alnwick. There seemed to be a long link yet required to join the districts described together, but this paper, by Mr. Lebour, would very much facilitate any endeavour which might be made to complete a detailed description of the limestones in the county of Northumberland. He was quite sure the meeting would agree with him that there were a very great number of interesting points which Mr. Lebour had brought before their notice. The fact of the thickening or thinning of the great limestone was very important, and also the thickening or thinning of the great scar limestone. Any one who had travelled through the county of York; in the western district of Craven, must remember that there, the great scar limestone takes an average of 100 fathoms in thickness, and when Mr. Lebour describes that he has not remarked much more than thirty feet of the Great Limestone here, in any one bed, it seems a very curious freak of nature. At *Aix les Bains*, in Savoy, which he happened to visit, there were the same series of limestones to 4,000 feet thick, and varying their beds as in Northumberland. He would have been very glad if Mr. Lebour had given some little further description of the metallic veins which extend through Northumberland, and which they believed to be a continuation of the metallic veins of Alston, for he should like to know why these veins are comparatively so unproductive in the former county. It seemed to be a very anomalous and difficult subject of inquiry why this change should take place, and why there should be so few lead mines in the county of Northumberland, where the same lead veins go through, which are so productive in the southern parts of the county of Durham. The question of the intrusive character of the whin sill he thought of extreme interest. He happened himself to visit the quarry described, which belonged to Sir Walter Trevelyan, and Sir Walter was particularly interested about it, and would, no doubt, appreciate the labours of Mr. Lebour in the event

of his deciding the question of the intrusive character of the basalt through these existing beds as they stood prior to its intrusion. At the meeting of the British Association in the year 1838, the question was very ably discussed by Professor Sedgwick, Professor Buckland, and other great geologists of the day. He thought that Mr. Lebour had quite clearly proved to-day from his very instructive diagram that the basalt did come through—that is, intruded itself between the layers of the limestone and the sandstone at certain points in its inclination through crevices, cracks, or small dykes, and had had the opportunity of extending itself through these layers in this particular fashion.

Mr. BEWICK said he joined with the Chairman in expressing his satisfaction at Mr. Lebour's paper, and in thanking him for it. He thought he would best consult the interests of the Institute by contributing in writing a supplementary or additional paper upon some of the points referred to by Mr. Lebour rather than go into a discussion at the present time. With the permission of the members, he would take an early opportunity of committing to paper the few remarks he had to make upon this interesting matter.

Mr. HOWSE said the only point he felt interested in just now was the very satisfactory manner in which the section at Elf Hills had cleared—or ought to clear—up the doubts of every sceptical mind as to the true character of the whin dyke. Professor Sedgwick was the first field geologist who investigated our district. He, in a very elaborate and very clearly-expressed paper, published in the "Cambridge Philosophical Transactions," came to the conclusion and expressed the decided opinion that it was an intrusive rock, from the survey he took of it at the head of the Tees, in Teesdale, and also from the examination he had made of some portion of the Cockfield Whin Dyke which travels the Egglestone Moor. Mr. Hutton, formerly secretary of the Natural History Society, had published a paper in the "Natural History Transactions," advocating an entirely different view, viz., that it was a regular layer, and had been poured out as a lava over the other strata; and since that time several other local geologists have advocated the same opinion. But no person who looked at it properly, and who had examined the section and seen the masses of shale enclosed in the bed of basalt at Falcon Cliffs, could have any doubt about its being an intrusive rock, and as to raising the difficulty that it had to force itself through so many hundred thousand feet of strata above it, that was just the very thing that would favour its intrusive power. But this section which the chairman and Mr. Lebour had mentioned to him a long time ago before it was exposed in the manner

it is now, he thought satisfactorily cleared up even to the most fastidious person the intrusive character of the rock.

Dr. PAGE said, with respect to the disappearance of the lead veins in these limestones, he had traced the formation to Scremerston and throughout the whole of the Scottish coal-field, and noticed that in no place except two had they any exhibition of lead : one was in Fife and the other near Bathgate. The lead veins at Bathgate were very early worked, and he believed were still working. The one at Blebo, in Fife, was frequently tried, but was never so productive as to make it worth while working. At these two points the limestone was closely associated with trap eruptions, and it might be worth Mr. Lebour's while to see how far the same conditions might hold good in Northumberland. In all thin limestones of 10, 15, 20, and 25 feet in Scotland, there was not a single trace of lead except at these two places, and these occurred in connection with the trap eruptions.

Mr. LEBOUR said, with regard to the Alston district, most of the lead, as he mentioned in his paper, was found in the Great Limestone, but he thought not in connexion with any eruption of the whin. In Central Northumberland he was not aware of any lead being in the Great Limestone. On this point, he thought the meeting had better hear what Mr. Bewick had to tell them.

Mr. BEWICK said, lead ore was found in Tynedale principally—but not exclusively—in the whin sill. He was himself now working it in what is believed to be the Four-fathoms limestone, and in some shale beds at a place easy of access, only two miles from Haydon Bridge, and the mine could be examined by an adit. He should be happy to see any of the members who might wish to observe the vein in its natural position in the limestone, sandstone, and shale beds.

The CHAIRMAN—But not in the basalt ?

Mr. BEWICK—No, the workings are not yet deep enough. The basalt is lying underneath ; but at the adjoining mines of Settlingstones, and Stonecroft, the principal products are from veins in the whin, but not confined thereto ; and the same thing occurs in Weardale, and Alston Moor. The lead ore is found to exist in all the different rocks including the whin sill. There is one mine in Alston Moor now being wrought in the whin sill—the vein passing through the whole of the overlying strata. At Mr. Beaumont's celebrated Burtree Pasture Mine, the whin sill is forty fathoms thick, and the vein is worked there through its entire thickness, and in that stratum is generally productive. Again, at the Slitt Mine, within a few miles of Stanhope, the same thing occurs. In fact, lead ore

veins are not affected or interrupted by the basalt. He did not mean to say but that the view Professor Page had propounded, that it was in the vicinity of the basalt that mines were most productive, might not be correct. He thought it probable, but the veins had evidently been formed subsequently, and passed through that rock without any interruption or hitch actually the same as in the sedimentary rocks. The Stonecroft and other mines were working in strata below the whin sill. As an additional reason for thinking it probable that there might be something in connection with the presence of igneous rocks so far as regarded the production of lead ore and minerals generally, he might mention that in some other countries he had visited, the most productive mines in the stratified rocks occurred in the immediate vicinity of porphyry or basalt. Veins of contact, as they are called, are where the porphyry and limestone or other rocks unite and form a vein, or dislocation in which, not unfrequently lead ore and other minerals are found, with limestone on one side, and porphyry on the other.

Mr. LEBOUR said, that since sitting down he had remembered one case in Northumberland, at Kirkwhelpington, where a lead vein was discovered many years ago, at the point of junction or contact between the whin sill and a limestone. But he thought that was the only instance that he knew. Some others might at first sight be thought to be connected with it; but it did not seem to be really so. Like the Bavington Mine, and others of that kind, they were found in lower beds and not directly connected with the whin.

The CHAIRMAN thought he was correct in saying that there was one lead mine in Scotland entirely confined to the whin sill—at Leadhills, in Lanarkshire.

Dr. PAGE said, if they took their most experienced authorities—Forsyth, who writes on the Alston veins, and Henwood, who writes on the Cornish—it was clear these veins were filled up chinks or fissures, and the two modes of producing them were either by trap eruptions or by contraction in the limestone. Now, where there are thick beds of limestone, there will be thicker veins, because there will be greater contraction in those beds than in the thin ones, and if there are not thick beds to contract, then there will be the trap eruptions in order to produce the chinks and fissures in which the veins are deposited. His remark was that, while thin beds of limestone did not allow sufficient contraction to produce veins, trap eruptions must produce them in greater abundance, to be subsequently filled by the infiltration of the lead and other ores generally found in the mountain limestone.

Mr. HOWSE said that the whin-sill terminated a little to the south of the Tees, and he thought that, between that locality and Derbyshire, there were no trap eruptions in the intermediate districts which were occupied merely by the sandstones and limestones. There were lead veins as at the head of Swaledale, and two or three other places, without trap eruptions. He did not say they had at no time been connected with underground igneous agencies, but that there was no trap at the surface in the district of North Yorkshire, between where the whin-sill terminates and the Derbyshire toadstone begins; and yet, between these two districts, there are lead mines, so that, if they are connected with the trap eruptions or volcanic eruptions, they are at a great depth below; and he mentioned this, because there was no doubt they had been connected with some volcanic agency, but whether it was nearer or further removed from the surface he could not say. Mr. Bewick had fully explained what any one could observe up in Weardale by going down the Burtreeford Mine, that the lead veins are of later date than the intrusion of basalt in this district.

Mr. BEWICK—This is clearly exemplified at Stonecroft, in Tynedale, and several other places. With reference to the remark of Mr. Howse, respecting the head of the Swale, there were no workings in any of the Swaledale or Wensleydale mines deep enough to reach the whin sill. The deepest working in any of these mines was somewhere about what is called there the fourth set lime—which he believed to be the Scar limestone, and the whin-sill was below the Tyne bottom limestone. There was no place in those dales where denudation had gone so deep as the whin-sill. The nearest was Gunnerside on the Swale, and there it is believed to be within a few beds. It was an extremely interesting point, and he hoped that in the course of time the Old Gang mines would penetrate to this depth, and prove whether the whin-sill is in the same position geologically as it is in the North of England; at the present time we are in the dark as to this.

The CHAIRMAN would ask Mr. Lebour one single question more: that was with regard to the identification of each bed of limestone. Was it Mr. Lebour's opinion that the fact of the existence of certain specimens of shells and remains, and the occurrence of that phenomenon in one particular bed, and not in another, would be sufficient to identify that particular bed throughout any length of country?

Mr. LEBOUR said—Well, if the only evidence of the identity of two beds was the occurrence of similar fossils in each, he should say the evidence was not sufficient in this district if that was really all; but

if there was even very slight stratigraphical evidence in addition, he should say that would complete the evidence, and make the whole thing certain. At the same time, if there should be found a shell in enormous quantities—a shell exceedingly common in one sill and always common in it, then when you found a second sill with that shell again very common, he thought it would be right to consider it the same. But if the shells were rare in both, they might very likely be distinct beds.

Mr. HOWSE said, in illustration, there was a fossil, *Gryphæa incurva*, which was characteristic of the Lower Lias from Redcar to Lyme Regis.

The vote of thanks was then put and carried unanimously.

The CHAIRMAN said, Mr. Simpson's paper on the Coal-fields of Russia was open for discussion.

Mr. LEBOUR said, that Mr. Simpson noticed that a very large coal-field formed part of the Altaï chain of mountains. He said it was in the government of Tomsk, and that he had no information respecting it. He might call Mr. Simpson's attention to a very elaborate paper, by a Russian Mining Engineer, Mr. Nasterowski, which had been published within the last month or two (since Mr. Simpson's paper was read) in the Annals of the Belgian Geological Society, and which gave very full particulars as to this coal-field. He mentioned beds of coal more than fifty feet thick, so that this coal-field must be of wonderful capacity.

Mr. SIMPSON said, there were two gentlemen appointed by the Vienna Exhibition to examine all the coal-fields of the world, and they give some account of this coal-field. They state it broadly to be the largest coal-field in existence. It was in Siberia, and the beds were of the thickness which Mr. Lebour had indicated, but he had no detailed information of it—simply what they said about it.

Mr. BEWICK supposed that being in Siberia it could not be worked.

Mr. SIMPSON—There are no railways to it. It was worked at present by people banished there. He had been unable to get the statistics since 1871, as to the production of coal in Russia; but he had the report of the Vienna Exhibition, which stated that the quantity of coal now worked in Russia, including Poland, was one million tons a year, which was an increase of 25 per cent. upon the previous year. He mentioned this simply to show that they were making steps to develop their country; and he heard the other day, from Moscow, that they are now enabled to increase the price of their coal about 20 per cent., which also indicated that the railway companies and other people are beginning

To illustrate Mr G A Lebour's paper on the "Great Limestone etc

FIG. 1

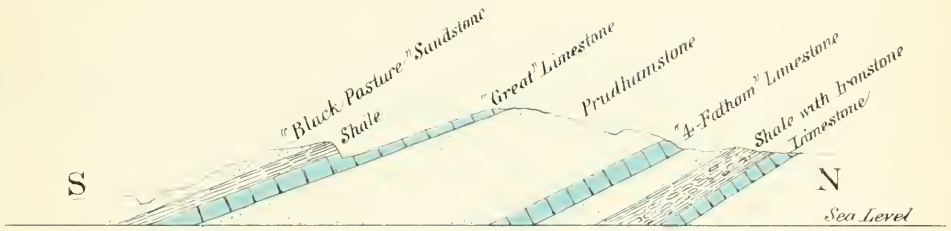
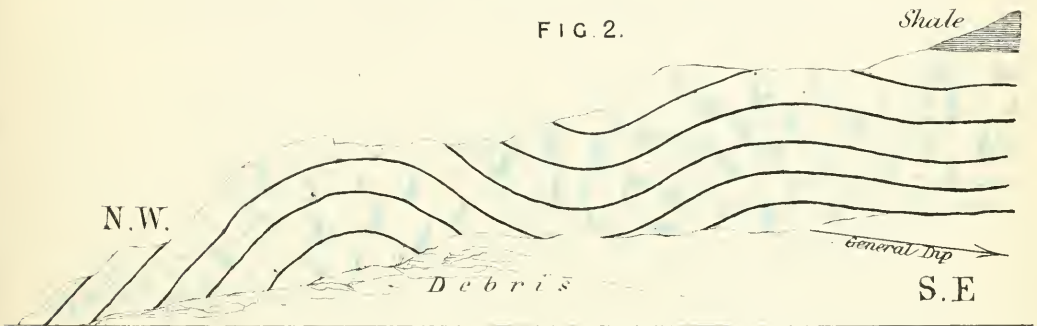


Diagram Section showing lie of Beds at Prudhamstone. (Real dip 10° to 12°)

FIG. 2.



Section at Brunton Quarry showing rolling of "Great" Limestone

FIG. 3.



Sketch Plan shewing lie of Beds at Grottingham

1. Fallowfield Fault and Vein dying out — 2. E and W Fault — 3. Small Fault.

To illustrate M. G. A. Lebour's paper on the 'Great Limestone' etc

FIG. 1. — Elf Hills Quarry, Northumberland.

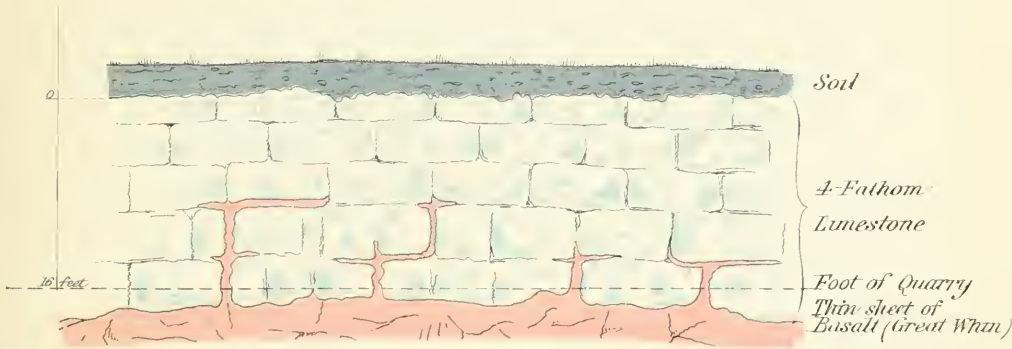


Diagram Section showing Shoots of Basalt protruded into the joint at the "4-Fathom" Limestone.

FIG. 2. — Same Locality.



Natural Size

*Block of "4-Fathom" Limestone with Sacrammina Carteri, Brady,
after H. B. Brady Esq. F.R.S.*

to look upon coal in a more favourable light. Of course, previously, as long as their forests would last, they preferred burning wood to coal, especially in the neighbourhood of Moscow, where they had large forests, which were, however, beginning to fail.

Mr. HOWSE asked if the members had heard of a bed of coal 100 feet thick, to the south of the Circassian range?

Mr. SIMPSON had not heard the thickness of it, but knew there were some beds there.

Mr. HOWSE knew of a gentleman who walked from the bottom of the bed up a burn to the top of it, and who stated that it dipped into the side of the hill, and was about 100 feet thick.

Mr. SIMPSON—Vertical thickness?

Mr. HOWSE—Vertical thickness. Of course he walked more in walking up the burn, and he said his great surprise was that it had never taken fire as it was surrounded by woods, which were very frequently on fire.

The CHAIRMAN said, if Russia became noted for its production of coal, some great change in the coal trade must be expected here.

Mr. BUNNING would like to ask Mr. Simpson if in his journeys in Russia and Germany, he had time to study the trades' organizations which existed in those countries? With the knowledge they had of the organizations here, it would be very interesting if they could compare them.

Mr. SIMPSON had not given his attention to the subject. He fancied, however, that our Northumberland men did not work such long hours as they do there. In Russia they work about twelve hours, except an hour in the day for meals, and in Germany generally he thought they worked pretty nearly the same time: at any rate about ten hours a day; but he thought our men worked harder than those men. He might say he did not think there was a Joint Committee either in Germany or Russia.

Mr. BEWICK said he never heard of any organizations in Austria or Saxony in connection with the coal miners.

Mr. SIMPSON said he had heard of a strike in Russia; it was not in connection with the coal mines, but the cotton mills. It went on for three or four weeks. The parties at last could not get the people to go to work, so the Government thought it time to interfere, and they sent every tenth man to Siberia and that very soon settled the strike.

Mr. Marley writes in reference to Mr. Simpson's paper, that he understood the amount of ash in coal of the Lithwinsk district to be about

8 per cent. With regard to the section of the coal at Gabucha, he observes, that according to his information the following is the section :—

								Ft.	In.
White sandstone	...	...	...	...	...	...	...	0	0
Shale sandstone	...	...	...	...	...	...	...	2	11
Coal	...	...	...	...	...	...	...	8	2
Shale sandstone	...	...	...	...	...	...	10 ft. to 12	0	
Coal	...	...	...	...	...	...	...	14	0
White sandstone	...	...	...	...	...	...	...	7	7
Shale sandstone	...	...	...	...	...	...	...	3	5
Coal	...	...	...	...	...	...	...	1	5
Shale sandstone	...	...	...	...	...	...	...	7	10
Coal	...	...	...	...	...	...	...	7	3

making an average thickness of more than 30 feet of coal.

Mr. Marley states, also, that he does not think women work in the mines, but only at the surface of the mines in this district.

The CHAIRMAN said, the paper by Mr. Daglish and Mr. Howse stood next for discussion.

The SECRETARY said he had a letter from Mr. Daglish, saying that from an unfortunate circumstance he had been unable to attend. Some of the iron manufacturers of the district promised to attend the discussion when it came on, and he thought Mr. Daglish would wish it to be adjourned.

Mr. HOWSE said he would rather postpone the discussion until Mr. Daglish could be present. He would be very glad to show the fossils to any one who wished to see them.

Dr. PAGE then read the following paper on—

SELENITIC PLASTER.

Dr. PAGE exhibited specimens of Selenitic Plaster as prepared by Stuart & Co., Edinburgh. This new mortar or cement, consists of an intimate admixture of hydraulic lime, gypsum, and silicious sand. Any hydraulic limestone of fair quality is calcined and mixed with five per cent. or thereby, of dehydrated gypsum; the two are thoroughly incorporated by being ground to a fine powder, and then worked up (by hand or by machinery) with five or six parts of clear sharp sand into a mortar. Portland cement and Dorset limestone were originally employed, but Messrs. Stuart & Co. find that several of the Scottish argillaceous or

hydraulic limestones answered equally well, and can be procured at a much cheaper rate. When laid on as a plaster, the cement sets, dries, and hardens in the space of twenty-four hours, and can be finished off with a fine smooth "floating" in course of the following day. It thus presents great advantages over the slow drying ordinary plaster and its successive coatings, and can be applied to brick and stone walls without any admixture of hair. As the "floating" can be coloured to any tint, the interior walls of a house can be rendered pleasant, dry, and fit for habitation immediately after construction—a thing impossible under the system of two or three coatings of common lime plaster. The selenitic plaster is also impervious to moisture, and never breaks or blisters as in the case of imperfectly slaked limes. Its cost was not greater than that of ordinary mortar. Dr. PAGE had witnessed its application in several large buildings in Edinburgh, and thought it admirably adapted for absorbent walls, and in all cases where speedy occupation of a new tenement was desired. Had it been used in the Mining Institute, for instance, access to that building could have been attained several weeks earlier; and instead of the unsightly efflorescence on the staircase, the walls could have been smooth and shining as marble.

Mr. BEWICK asked what was the cost?

Dr. PAGE said, it was about the same as the ordinary mortar.

The CHAIRMAN asked if it had been applied to the building of the exterior dwellings of a house structure? He saw that lately some had been built entirely of composition.

Dr. PAGE did not think it would stand the weather: it was more suitable for inside work. In the event of erecting a colliery row of sixty or eighty houses, it would be an advantage to use this, as it would be perfectly dry and impervious to wet in the course of three or four days.

The CHAIRMAN asked what thickness it would require to be put on?

Dr. PAGE said, it could be put on any thickness—a quarter or half an inch; it was then floated over to perhaps the 16th of an inch, and presented a fine smooth surface like marble.

Mr. BEWICK—The thicker it was put on the longer time it will take to dry.

Dr. PAGE explained that the composition had rapid drying power. They used to have the blue lias from Lyme Regis; but Stuart & Co. were now using the hydraulic limestones of Scotland.

Mr. BEWICK asked if the specimens were made from the blue lias limestone?

Dr. PAGE—No; they are made from the Scotch limestones—the carboniferous blue limestones.

MINERA FIRESTONE.

Dr. PAGE also exhibited specimens of the Minera Firestone—a medium-grained sandstone from the millstone grit of the Berwig Mountains, near Wrexham, which had obtained a high reputation in the midland and western counties as a fire-proof material for glass, chemical, and iron furnaces. Natural stones capable of resisting intense heat, and especially intermittent heats, were very rare (potstone, asbestos, leekstone, &c.); and hence the frequent manufacture of such substitutes as ordinary fire-bricks, silicated bricks, Dinas bricks, and the like. Natural stones, however, had many advantages in point of size, facility of being shaped to any form, &c., and were generally preferred, when obtainable at a moderate cost and of sufficient durability. The following is an analysis of the Berwig stone, by Mr. Bamber, of London; but the refractory nature of such sandstones depend more, perhaps, on their texture than on their chemical composition:—

Silica	...	..	...	...	...	...	...	85.05
Alumina	...	...	...	...	...	...	...	8.25
Iron oxide	...	...	...	...	...	...	...	2.30
Lime	...	...	...	...	...	...	...	1.00
Magnesia	...	...	...	...	...	...	...	0.75
Alkali	...	...	...	...	...	...	...	trace.
Water and organic matter	...	...	...	...	...	...	...	2.22
								<hr/> 99.57

The CHAIRMAN said the Aid Crag, on North Tyne, was very remarkable, it being a very fine freestone.

Mr. SIMPSON said, there was a bed of freestone underneath the fell top limestone, which was used in smelting works.

Dr. PAGE said a natural sandstone had always the advantage over silicated bricks and the like, as it could be shaped to any form. Naturally firestones were not very abundant, and it might be worth while in the

carboniferous workings of Durham and Northumberland to look out for beds possessing this quality.

Mr. HOWSE said he believed the good quality of sandstone arose from the quantity of soda and potash in it.

The CHAIRMAN—Forming the surface Dr. Page speaks of?

Mr. LEBOUR said, another very excellent firestone was found not many years ago at a place called Cotter Heugh Crag, Clarebough. That was higher than the Aid sandstone—to the north of Bellingham, near Hareshaw.

The meeting then separated.

PROCEEDINGS.

GENERAL MEETING. SATURDAY, MAY 1. 1875, IN THE WOOD
MEMORIAL HALL.

MR. STEAVENSON, VICE-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting, and of the Council meeting.

The following gentlemen were then elected :—

MEMBERS.

MR. THOMAS RUTTER, Blaydon Main Colliery, Blaydon-on-Tyne.
MR. MARTIN HALLIDAY, M.E., Peases' West Collieries, Crook.
MR. JOHN D. WARDALE, M.E., Redheugh Engine Works, Gateshead.
Mons. DABURON, Ingenieur aux Mines de Nœux pas de Calais.

STUDENTS.

MR. FRANK DORMAN, Stanley Colliery, Crook.
MR. J. J. PREST, Belmangate, Guisbro'.
MR. ROBERT J. HARRISON, Silksworth Colliery, Sunderland.
MR. THOMAS E. CANDLER, East Lodge, Crook, Darlington.

The following were nominated for election at the next meeting :—

MEMBERS.

MR. CHARLES E. PARKIN, Perran House, Perran Porth, Truro, Cornwall.
MR. CHARLES JOHN BAGLEY, Tees Bridge Iron Co., Stockton-on-Tees.

STUDENT.

MR. ARTHUR MUNDLE, 7, Collingwood Street, Newcastle.

The CHAIRMAN said, Messrs. Daglish and Howse's paper would now be open for discussion, and Mr. Adamson, who had come from the Lincolnshire district, would be very glad to afford any information in his power to the members; they were also indebted to Mr. Howse, who was one

of the readers of the paper, for various specimens of fossils in illustration. This was almost the only iron-producing district of the country which he himself had not seen, and therefore he could not say very much about it. He had read the paper, though not so carefully as to be able to cross-question Mr. Daglish or Mr. Howse upon it; but perhaps they could tell the members whether there was any trace of the Cleveland beds in that district, or whether they had been tried for, at any time. As he understood it, the ironstone of that district was of such a peculiar nature that it was an advantage to mix with it the iron ore of other districts. That, of course, was somewhat of a drawback; but up to the present time, the very cheap cost at which it had been raised had assisted it so much as to enable them to produce iron of marketable quality, and at such a price as to enable them to carry on the works. In Cleveland, in 1852, when they began to open out the mines, they worked very much from the outcrop, as they appear to have done in Lincolnshire; but he imagined that in the time to come, in Lincolnshire, as in Cleveland, this would be otherwise. Perhaps, if he was mistaken in that view, the writers of the paper would be kind enough to explain it.

Mr. DAGLISH said, in the short discussion there was on that paper at Cardiff, there were some questions raised as to the operation of the limestone on the ore; and Mr. Adamson, who had worked that stone very extensively in the furnace, was not present at the meeting, otherwise he thought he would have been prepared to have given some facts about the large quantity of lime in certain parts of the bed.

Mr. ADAMSON said, he had not the honour of being a member of the Institute; but promised Mr. Daglish to explain anything which experience might have taught him appertaining to the peculiarities of that bed. It was composed of ironstone and limestone 22 feet thick: the limestone was fossiliferous and consolidated, and the ironstone was an ore of a rotten or unconsolidated class, fortunately containing few fossil remains, and hence but little phosphorus. The iron from the selected stone could be made with as little as .08 per cent. of phosphorus. Taking the fossiliferous stone and using it as flux, would raise this to 1.27 per cent., not very far from the measure of phosphorus found in the better beds of the Cleveland stones, and hence in that particular it had nothing to boast of as regarded quality. But it had some exceptional conditions or ingredients which were valuable for the manufacture of pig iron for forge purposes, as the lower class of stones contained from 2 per cent. up to nearly 8 per cent. of manganese; and in cases where great

attention at selection had been made, even speigeleisen of a moderate quality could be manufactured. He believed he was speaking the exact truth when he said that it had not been a profitable iron-making bed. Those gentlemen, who had invested their money, from Middlesbro' and other districts, where the minerals were much more uniform had not succeeded as they had done at home. Two or three feet of the upper part of the bed was in appearance a sandy ironstone of a high class quality, containing fully 39 per cent. of metallic iron, while its earthy base did not exceed 14 per cent., and this was found on the top of the quarry. It also carried with it some 28 or 29 per cent. of water, and hence, so far as the working of the ironstone was concerned, it would be easily comprehended that it was rather difficult to manipulate in the close topped furnaces of the Cleveland district, and to utilize the gases while such an enormous quantity of steam was being driven off; for this steam and a probable over-dose of carbonic acid, from using an excess of lime stone, would scarcely support combustion. The bed had clear distinguishing characteristics as he had named, and some few were present through the whole of its depth. The first portion of the sand-like ironstone contained about 40 per cent. of iron, the next band not more than $12\frac{1}{2}$, and then came the question whether this bed, where the iron only amounted to $12\frac{1}{2}$ per cent. to 68 per cent. of carbonate of lime, should be called an iron bed or not. He believed the cause of the great losses that had occurred in the Lincolnshire iron-field was making iron at random, and using the stone promiscuously without the slightest consideration as to the results, and filling in at the top of the furnace minerals of a variable, mechanical, and chemical character, from which it was thought a uniform result could be obtained from the bottom. The third bed might be considered a very fair ironstone, as it contained with its enormous quantity of water 33 per cent. of metallic iron, and carried with it exactly the amount of lime requisite for smelting. Stated broadly, the difficulty of making iron in Lincolnshire was the amount of slag produced. There was an enormous quantity of earthy matter to be dealt with, and then came the fact of what was to be the proportion of the several sections of the bed to be put into the furnace to get a result sufficient under all conditions to produce a fluid cinder. He had to thank Mr. Mushett, a gentleman whom he believed most of them knew as being one of the most eminent metallurgists in this country, for his advice in reference to the manufacture of pig iron in Lincolnshire, and to the neutralization of the large quantities of lime by the use of the silicate of alumina or ordinary brick clay. The resulting slag produced from working that stone would often

show as much as 20 per cent. excess of lime. That, in his opinion, would not give a fluid cinder; and he arrived at this conclusion, that whatever were the elementary properties of the minerals which they had to manipulate, the lime must be equal to the whole of the alumina, plus half the silica, as long as there was an absence of magnesia; and he believed that the ironmasters, either at Middlesbro' or elsewhere, had to act on a formula very nearly approaching this, to make the whole of the foundry iron produced in this country; and it would be easily seen from this, that where a professedly called ironstone contains as high as 68 per cent. of carbonate of lime, and only 12 or 8 per cent. of metallic iron, it became serious, unless there was a neutralizing element to combine with the lime in the furnace. He fancied their chairman would be better acquainted with this matter than he was; but he spoke practically from his own close observation. The furnaces when receiving a fair charge of limestone worked rapidly for a few hours, then an enormous generation of carbonic acid was produced which appeared to almost extinguish the fire. In the first case, when working hot, they got lime at a high temperature seizing hold of the fire bricks, forming silicate of lime, burning out the tuyers, destroying their hearths, or playing havoc with the working practical condition of the furnace. Then after that, when the excess of lime came down, the cinder would not separate from the iron, and they were again in difficulties. The hearths filled up, and like the rest of their neighbours, they got into that very undesirable condition of rapidly losing their money, and hence their great iron ore district, exposed as it was over several square miles and merely covered with sand, was a mere rabbit warren, and had not been worked with that efficiency which sensible, scientific men, at any rate, ought to have attained, and heavy losses had been sustained. He had pointed out to them, to some extent, the difficulty that arose from this great excess of limestone, a difficulty which ought not, in his opinion, to arise if the ore was properly selected. When this had been done the resultant iron had been beyond their expectation; as a rule it contained at any rate one to two, and he thought the paper gave two to three per cent. of manganese, and hence they had been able to sell their iron for metallurgic purposes, and more especially for the manufacture of wire, hoops, and as a mixture for tin plates, and he believed this had arisen in a large measure from the manganese it contained. He need hardly say that being of a manganiiferous character, the iron itself was not so useful as a foundry iron alone, as manganese always existed in it to such an extent as to make it work with difficulty under the file. For instance, a

second-cut file used upon a piece of cast Lincolnshire iron, would lose its power of filing in three or four minutes, and he thought that this must arise from the manganese in the iron. The gentleman who made the thief-proof safes at Bolton, in Lancashire (Mr. Chatwood) filled the spaces between the plates with broken-up spiegeleisen, and those gentlemen more especially engaged in mechanical engineering would no doubt have had it before them that it was utterly impossible to drill spiegeleisen. The hardest steel he had ever seen would scarcely touch it. Hence, if spiegeleisen containing, say from eight to twelve or fifteen per cent. of manganese, could not be either drilled, filed, or cut at all, it was only a rational conclusion he thought to arrive at, that the Lincolnshire iron containing two or three per cent. of maganese should have some of the characteristics that were connected with the incorporation of manganese; and certainly on that point it did possess that steely hardness which makes it unfit for use as a foundry iron alone. Nevertheless it had some good mechanical properties in this way — for, if a solid, polished, and slippery surface was required, it had all the properties which produced an exceedingly close, dense, and durable iron, which might be used for locomotive cylinders for example, and thus became of very considerable importance. He was not quite sure whether it was due to the manganese which was in it, but it also ran with a slightly greater fluidity than the Scotch irons, and in that particular it was mixed occasionally with the more sluggish irons of Cleveland to run into small castings. It polished exceedingly well, and became very bright, and for purposes of that sort it was also useful; but for any purpose where the file had to be applied it was not wise to use Lincolnshire iron in large quantities. He did not know that he need say any more on the peculiarities of the Lincolnshire iron as iron. He was quite sure from his own experience that the paper itself was exceedingly truthful. The ironstones referred to, both in Frodingham and north of the cathedral of the city of Lincoln, were most accurately described. He could hardly say so much for those at Caythorpe; and he was somewhat at a loss to understand, or to fully comprehend the position of bed No. 4, as described in the paper. He had not had an opportunity of examining the pit at Coleby at all, neither was he aware, until the paper was sent him the other day, that such a pit had been sunk on the edge of the cliff, in a central position between the city of Lincoln and Grantham; but he had had frequent opportunities of examining the district around Grantham, and also the whole of the lias outcrop there, down to the new red sandstone which forms the plateau between Grantham, north of the tunnel

on the line of railway to Nottingham ; and in some remarks which he made before the Iron and Steel Institute, at Barrow, he called attention to the fact which, he believed, would be fully borne out, that the lias ironstones near Grantham were the nearest to the south of Nottingham coals, of any mineral for making iron that exists in this country, exclusively, of course, of those belonging to the coal measures so largely found in North Staffordshire—he meant those of the lias or oolitic classes. Those who knew that district, standing anywhere in the neighbourhood of the city of Lincoln, might trace the line of outcrop by the village of Normanby, and past Market Rasen of a large field of this class of stone, whatever its quality might be. He had the opportunity some years ago of examining it, and he concluded it was of a fair average quality ; but again there would be, in working it, some of those difficulties which were common to the Lincolnshire lower bed, which was interstratified with fossiliferous limestone. He did not know that he could say any more which would interest them. If he could say anything appertaining to the minutiae of the iron, and could give any such information, he would be glad. He might just remark further that at one time they worked the upper ironstone bands in the main Frodingham bed, those more especially clear of phosphorus ; and the resulting iron did not contain more than '08 of phosphorus. He sent a few tons of that to a Bessemer manufacturer, and with a small admixture of west country cast iron, he got, he thought, something like three or four working ingots out of eight or ten made ; but it could not be sufficiently depended on to be of practical value, although with more care, in the selection of the ironstone and flux, iron might be made to use as a mixture in the Bessemer connector.

The CHAIRMAN said, the paper, combined with Mr. Adamson's remarks, gave a very fair account of the district of Lincolnshire, and he thought that such additions to the papers of the Institute were very valuable, as most of the members were frequently called upon to go into strange districts and observe and speak upon them, and to them such a guide as the paper and the remarks of Mr. Adamson, must prove very valuable. Although it was almost the only iron making district he had never seen, yet still he thought from what they had heard, some of them might be induced to go and see it for themselves during the next summer, and it would certainly be a district which would repay them for going. He suggested that the least they could do was first to ask Mr. Adamson to join their Institute, and next to pass him a vote of thanks. He was quite sure that if Mr. Adamson would allow his name to be put upon the list of members, he would be a very valuable acquisition.

A MEMBER asked if Mr. Adamson had used any admixture with the Lincolnshire ore ?

Mr. ADAMSON—Yes. In the first part of his statement he said they used silicate of alumina, and it was ultimately found very desirable to use natural silicate of iron, and for that purpose they obtained some of the outcrop stone north-west of Malton from Mr. Walduck, but this contained a certain amount of lime which neutralized some of its good qualities. They then fell back upon the ore that was worked in what was called Monks' Lane, close to the city of Lincoln, which was nearly of the Northampton composition, and was found on analysis to contain never less than 42 per cent. of metallic iron, and from 12 to 20 per cent. of silica. They used one-eighth or one-tenth of that stone at present, and since they used it they had much less care and anxiety in throwing out the rough or consolidated phosphoriferous limestone from the natural bed, besides which the silica neutralized the lime, and they had now got a fair running cinder with an iron-producing material, and he might also say that since that operation was performed they had been much steadier and much more healthy in the furnace. Had it not been for obtaining this ironstone with a very large amount of silica, he was quite sure the works he had the honour to represent as chairman, and which principally belonged to himself, would hardly have been in existence at present. It was a bed of valuable iron ore, but interstratified with limestone. If the gentlemen present would like during the summer to go and see it, and would apply to him, he would have very much pleasure in giving them an introduction to the gentleman who managed the works, and who would show them the furnaces and the ironstone bed.

The CHAIRMAN asked if he understood Mr. Adamson to say the Kirkham ironstone did not suit ?

Mr. ADAMSON—Not so well. It contained some considerable lime and alumina, while they wanted more silicate ; and then it only contained about their own measure in Cleveland of metallic iron, say 32 per cent. The other on analysis they never found to contain less than 42 per cent. of iron, very little alumina, not much lime, and a large measure of silica.

The CHAIRMAN said, he happened to know something about the Kirkham ironstone, and had occasionally been there himself ; but the great difficulty there was, it was too siliceous. It appeared to him that if the two were used conjointly and with a certain amount of skill it might be successful.

Mr. ADAMSON said, they had used it with success, but they found that the other gave them a better result commercially. Had they not found a better stone, it would have been the one selected as a mixture.

The vote of thanks to Mr. Adamson and the readers of the papers was then put, and carried by acclamation.

Mr. W. LISHMAN, Etherley, read the following paper on "Electric Signals on Underground Engine Planes":—

ELECTRIC SIGNALS ON UNDERGROUND ENGINE PLANES.

BY MR. WILLIAM LISHMAN.

CONSIDERABLE inconvenience was felt at the Etherley George Pit for want of some mode of signalling other than those in use at that time, owing to the length of the underground engine plane.

The writer consulted Mr. John Henry Greener, of St. Swithin's Lane, London, who put down an electric signal in 1866, which consisted of one of Mnirehead's Batteries, with twenty-four cells; the outer cells were porcelain, the inner cells were porous and made of fine common clay, sulphate of copper (blue stone) being used as an exciter; the plates were made of zinc and copper. This battery was placed in the engine-house at the foot of the shaft. A bell or gong was substituted for the dial plate, and signals were expressed by striking one, two, or more successive blows on the bell or gong, simply by pressing down a knob at either the terminus or other station. The insulators were made of earthenware, and were affixed and so shaped on the exterior as to admit of a stretcher being applied at pleasure to stretch the long circuit wires from insulator to insulator. Two galvanized iron wires ran the whole length of line from the underground engine-house to the engine station, a distance of two miles, where a transmitting apparatus was fixed to signal out-bye.

There is scarcely anything which facilitates the transit of coals from the workings of a colliery so much as an easy mode of signalling from the hauling engine to the terminus of the plane.

The advantages claimed for this mode of signalling are—cheapness of construction, great simplicity, and non-liability to mistakes and disarrangements; the signals can be given at any point on the line, either by rubbing the wires together, or by connecting them with a piece of clean wire, a metallic rule, or by any good clean conducting substance.

Thinking that, owing to the importance of the subject, a short account of other two electric signals in use at this colliery might be of interest to the members of the Institute, the writer will give a brief account of them.

They are Léclanché patent batteries, specially adapted for the purpose, and such as are largely employed by the Continental and English Railways, and the Post-office. This battery arrives quickly afterwards at

its maximum strength, and its electro-motive force is 75 per cent. greater than the Daniel Battery, whilst its resistance is 90 per cent. less. For constancy, durability, and cleanliness, it is unequalled.

The following directions for charging should be carefully adhered to:— Fill the glass about half-an-inch high with powdered sal-ammoniac, put the porous cell in its place, and half fill the glass cell with water, pouring a little water into the porous cell also through the holes on the top. The battery will remain in working order so long as the solution is clear and in contact with zinc. When the solution becomes turbid or milky, add sal-ammoniac, and in a few hours the battery will be as powerful as ever. It may be placed aside for months without deteriorating. Special care should be taken that the porous cell never stands more than half its height in the liquid.

In 1872, one of these batteries was placed at the surface near the engine, and two coated wires were run 76 fathoms down the shaft; from the bottom of the pit two ordinary galvanized iron wires were taken in-bye to the terminus, a distance of about 800 yards. There are three stations where bells are attached to this battery; one at bank, another about 400 yards in-bye at the top of a steep bank, and the other at the terminus or station. Signals can be given from either end of the line, or at any point as before described.

Last year another of the Léclanché batteries was put down by one of our own men, who has had the management of these electric signals, and is capable of keeping them in proper order. It consists of a battery placed at the surface in the engine-room; from thence two galvanized iron wires are taken down a slope drift 400 yards to the working shaft, where a bell is placed for signalling to bank. From thence wires are run along the line to the bank top, a distance of 1,600 yards, where the tail-rope is knocked off. A bell is also placed here for signalling both in and out-bye; two wires are taken from thence to the bottom of the engine plane, a distance of 500 yards; a bell is also placed here for giving and receiving signals direct to and from the engineman at surface or bank top, or *vice versa*. These signals work very regularly, unless any mischievous person tampers with the wire. When they were first introduced much inconvenience was felt from this cause; but now, since the workmen had become accustomed to them, and the novelty has died out, they do not interfere.

A MEMBER asked if this system had ever got out of order? Had it ever failed to act?

Mr. LISHMAN said, it was like all other systems, it got out of order

occasionally ; but it had been found that the great point was to attend to the batteries. They had no other means of signalling on three very long planes.

The CHAIRMAN asked if Mr. Lishman would say as a rule, how often they required to attend to the batteries ?

Mr. LISHMAN said, about every six months they had to be charged in the charge-room.

Mr. DAGLISH said, batteries something similar to this were in operation in a colliery in which he was interested in Wales, and seemed to answer remarkably well, and they had been there for two or three years. In going down the deep angles of the plane, the wagon rider, if there was anything the matter jumped off, put the two wires together, signalled immediately, and stopped the engine.

Mr. LISHMAN said, they could do the same if anything occurred with the set.

Mr. HEDLEY asked whether, as they used the same set of wires connected in one case with three or four different stations, similar signals were not communicated to all the stations at one time ?

Mr. LISHMAN said, they could stop the set if anything was wrong, and then they must put themselves right afterwards by giving the proper signals.

The CHAIRMAN said, it was a branch of engineering to which they had not yet had their attention called, although he imagined there were several instances in which underground telegraphs had been resorted to. He himself had done it in one case already, and had proposed that day to do it in another case before coming to the meeting, but when he first arranged to have a telegraph underground at one of the collieries—Page Bank—it appeared to him that there was so much risk of its being interfered with if the two wire system was used, that he adopted the single wire, and that had worked very well, and if they were able to get a communication with the engineman, could be immediately restored in case of accident, and could not be so readily tampered with ; but of course, as Mr. Lishman said, after a time the boys gave up playing tricks with it, and then he had no doubt the two wires would have advantages. He supposed they would defer the discussion until the paper was printed.

A vote of thanks was then passed to Mr. Lishman.

The CHAIRMAN said, Mr. Galloway had come here from a considerable distance to be present at the discussion on his paper, "On Safety Lamps and Shot Firing."

The SECRETARY said, in reference to this paper, he had a communication from Mr. Greenwell, which that gentleman had asked him to read. Mr. Greenwell had written a paper for the Manchester Geological Society's Transactions on the use of gunpowder in mines, which possibly Mr. Galloway might have read. Mr. Greenwell wrote as follows :—

POYNTON, *November 30th, 1874.*

DEAR SIR,—As I shall be unable to attend the next meeting of the North of England Institute, I shall feel obliged if you will be good enough to say for me what I should have said if present, with reference to Mr. Galloway's paper on sound waves in connection with colliery explosions.

I am entirely unconvinced that the passage of flame from the interior to the exterior of the Davy lamp was due to a "sound wave."

I think it was simply due to the forcing forward suddenly of a current of air through the gauze, by the action of the air propelled against the diaphragm placed in the tube, by the pistol shot. That such action actually took place would have been abundantly proved by a valve opening inwards, placed on the tube between the pistol and the diaphragm.

To assimilate the case to that which it is endeavoured to be proved is analogous to colliery practice, let the pistol be fired in the open room *without the tube*, and then if the sound wave causes the flame to pass I will (but not till then) believe there is *something* in Mr. Galloway's theory. Of course the pistol must be fired, not at the lamp, and at a reasonable distance from it.

The concurrence of explosions of fire-damp with shot-firing, is in my opinion to be accounted for, but on a very different principle.

I remain, dear Sir,

Yours very truly,

T. W. BUNNING, Esq.

G. C. GREENWELL.

It was to be regretted that Mr. Greenwell was not present, because he saw by his paper that he accounted for the passage of the flame in another way.

Mr. WALLACE said, the subject of the paper was no doubt one of the greatest importance to mining engineers, and he was very happy to have the opportunity of making a few remarks upon so interesting a subject. The question which had just been raised concerning the causes which extinguish the light after explosions, seemed to be divided into two distinct parts—one which referred to the explosion and the movement of the air produced by expansion and contraction, and the other which was due to the passage of the sound wave. He believed that according to Tindall's explanation of the transmission of sound there was no movement in the air, and the light would be first affected according as it stood in the air between the nodes representing

the beginning and the end of the several vibrations which carry forward the sound. Suppose if the light were in the node at the beginning of the wave it would not be affected. If it were at the middle of the node it would be most affected, and so on at each node the light might escape the effect which in another place would extinguish it. That was irrespective of the distance from the centre of the explosion. The opening sentence of the paper seemed to be capable of more than one interpretation ; probably the author of the paper would explain it. Upon the whole he found it very difficult to know what was the drift of the paper, and what it suggested. If safety-lamps were dangerous, there was no alternative offered, and the actual cause of the explosion of a safety-lamp under the conditions seemed almost as remote as before. However, a subject of that sort he thought was too important to fall into abeyance, and he had no doubt some useful information might be elicited at the present meeting.

Mr. GALLOWAY, in reply, firstly in regard to Mr. Greenwell's remarks, might say, that gentleman did not seem to have perused the paper sufficiently, otherwise he would have seen there were certain experiments made in a sewer in which the shot was fired at a distance of 100 feet from the light. There was no diaphragm in that case. Besides, if the diaphragm causes the sound wave, it came to quite the same thing as if the pistol-shot caused it. It was only a wave sent along the tube either by the pistol shot or the diaphragm. The diaphragm transmitted it ; but did not cause it. In regard to Mr. Wallace's remarks, he would say that when Prof. Tindall talked of nodes, he referred to a succession of sound waves of equal length ; but between the nodes the air had a movement, and at the central point between two nodes the movement was greatest—a backward and forward movement. The object of the paper was simply to show that lamps which continued to burn in an explosive mixture, and were liable to have the flame driven through them by sound waves, were not safe when placed in explosive mixtures when shots were fired in the neighbourhood, and he thought the object was quite evident without any necessity for explaining it.

Professor MARRECO said, he had worked a good deal since Mr. Galloway's paper was read, and one thing which had strnck him was, that he had very great difficulty in getting uniform results with the tube experiments. They had satisfied themselves as to how very little made a difference between success or failure, and, therefore, he thought the experiment in the sewer, which Mr. Galloway had just referred to, where the pistol was not pointed at the lamp but at the roof, was far the most satisfactory of the series.

The CHAIRMAN—In that case you approve of the sound wave theory ?

Professor MARRECO—Well, that is rather a question for mathematicians, I think.

Mr. DAGLISH asked if this theory could be tested in a tunnel or long drift as well as in a sewer ?

Mr. GALLOWAY thought it would come to the same thing.

Mr. DAGLISH said, because it would be exceedingly interesting to a large number of members if they could see it. There was perhaps in the mind of every one, the doubt raised by Mr. Greenwell as to whether it was not the force of the explosion rather than the sound wave ; but if they could see it done in a sewer, he was sure it would be very convincing—not gratifying, but the reverse—but still if they had to elicit the truth, the sooner they knew it the better.

Mr. GALLOWAY said, of course Mr. Greenwell called it “the force of the explosion,” and that was simply another way of expressing the phenomenon which accompanied the sound. The “*force of the explosion*” and the “*sound wave*” were simply one and the same thing.

Mr. WALLACE said, referring to one of the experiments made during the reading of the paper, a difficulty suggested itself to him in the application of the lesson learnt during the experiment. At one time the explosion from the pistol ignited the gases escaping round the lamp ; at another time the explosion of the pistol was sufficient to extinguish it. They might take that as an expression of a varying force acting (without having to define the force particularly) at a fixed distance ; or they might represent it as the same force acting at different distances. Now it would appear from that experiment, that if the lamp were placed at a certain unknown distance from the explosion the flame of the lamp would ignite inflammable gas outside the gauze ; but at all other distances no accident would follow, whether the lamp were extinguished by the force of the shot or not. With such results before him, a miner of average recklessness would regard the chance of being hurt so small, when compared with the many chances of escape, that he would be rather encouraged to run the risk if he thought it would save him any trouble.

The CHAIRMAN said, the question was also mixed up with the effect of blown-out shots ; and was the subject to which Mr. Greenwell called the attention of the Manchester Geological Institute in 1870. He remembered reading the paper ; it rather attracted his attention, because he had had some experience of the effect of blown-out shots several years ago. The late Mr. Atkinson, whose opinion he always very much esteemed, differed from himself as to the effect of such shots. He (the

Chairman) happened once to be in a bord which had just been turned out to headways ; he examined the place carefully, and satisfied himself there was no gas ; and then lighted up a very heavy shot. He happened to be standing at the bord end. The shot was fired, and the flash coming away, burnt a man who was standing close to him. Now the question arose whether there had been any gas, or whether it was a blown-out shot ? Upon a careful examination it was found that there were the marks of the pellets of the gunpowder on the sides of a tub near him, and he was also burnt in a manner which led him (the Chairman) to think there was no gas. But Mr. Atkinson would never agree with that opinion. He seemed to be inclined to think that eight or ten yards from the shot was too far off for the flame to have affected him. Since then, he had always inquired into any case of the sort when it occurred, and he had found very often that the flame from the shot had been seen to the distance of thirty yards. Whether the lamp was ignited by the wave from the sound, or was ignited by the concussion in the air did not matter practically, although it did perhaps scientifically. The question put to them to solve was, whether from the wave sound or from the concussion of the air, the common Davy lamp which they used was unsafe. He certainly thought no case had yet been shown which would induce him to do away with the Davy lamp in favour of the more complicated lamp with a glass, because the glass itself introduced an element of danger. It might crack, or break, and cause an accident at any time. However, this question of blown-out shots was one which either now or at some future time, he thought the Institute ought to pay attention to. He thought that whether Mr. Galloway was right or wrong they were very much obliged to him for having brought the subject before them, and it would always form a matter for their consideration when occasion brought it to their notice.

Professor HERSCHEL thought it a pity that any doubt should hang over Mr. Galloway's paper, as regarded his view of the nature of the sound wave, that it contained all the motion of the shot in itself, whatever the nature of that original motion was. The statement of Mr. Greenwell that he was able to account for it on another principle was one that he was sure would engage their interest very thoroughly. If such a paper were read, it would give a new occasion to renew this question, and to make it clear to all the members present. But the result would only prove, as Mr. Galloway had endeavoured to show them, that the escape of the gas from a free shot was very much more violent than when the shot was damped, and that the motion from the former might be sufficient to produce the ignition of inflammable dangerous gases. The principle upon

which Mr. Galloway had proceeded was, he thought, irrefragable, and they could, without reservation, thank Mr. Galloway for the pains which he had taken to show them the experiments he had made, and their dangerous effect in certain cases ; and the caution which Mr. Galloway gave was, he thought, a sound and very valuable one. He should hope that Mr. Greenwell's views on the question might be introduced at some future time.

Mr. BUNNING asked Mr. Galloway if he had seen Mr. Greenwell's paper.

Mr. GALLOWAY said he had not.

Mr. BUNNING said, it would be very interesting if Mr. Galloway were to read it through, and on some future occasion favour them with his presence, and give them his opinion as to the other causes suggested by Mr. Greenwell.

Mr. COOK had great pleasure in moving a vote of thanks to Mr. Galloway, which was carried unanimously.

The following paper by Mr. Edwin Gilpin, M.A., F.G.S., "On the Submarine Coal of Cape Breton," was then considered as read and ordered to be printed.

THE SUBMARINE COAL OF CAPE BRETON, N.S.

BY EDWIN GILPIN, M.A., F.G.S., ETC.

THE object of this paper is to describe the extent and accessibility of that part of the Cape Breton coal-producing strata which extends under the Atlantic and Gulf of St. Lawrence.

At the present date in the history of the Cape Breton coal trade, when the large deposits known to exist inland are scarcely opened out, this may appear a premature speculation. The subject, however, is exceedingly important, for it will be shown that the best seams, the highest in the series, extend but a comparatively short distance inland, and as far as present research extends, the submarine areas must furnish the finest coals of the future.

The data furnished by the reports of Professor Lesley, Dr. Dawson, and others, on Mr. J. Rutherford's "Coal-fields of Nova Scotia," as well as the private reports of the writer, will be used for the basis of this paper. The clauses of the Provincial Law relating to submarine workings will be given; and the systems of working at present pursued will be described as fully as possible.

Mr. Rutherford's paper on the Nova Scotia Coal-fields, read before the Institute in 1870, describes graphically and carefully the three undulations, called the Sydney, Glace Bay, and Cow Bay synclinals, which form the most striking geological features of this district; and all the leading points in the various seams worthy of notice. Few, if any, coal-fields present finer natural sections than those exposed in the cliffs of Eastern Cape Breton, or have had the advantage of being more carefully examined; this has permitted a precision and certainty in the identification of seams not generally attainable. This coal-field extends from Cape Dauphin to the metamorphic rocks of Mira Bay, and presents the form of an irregular triangle, the eastern edge of which is jagged and uneven, while the outcrop of the underlying millstone grit forms the western boundary. The area of the field may be calculated at 200 square miles, the greatest width being five miles in the Sydney and eight miles in the Glace Bay district.

Plate XXXIV. shows a line drawn parallel to the shore at a distance of one mile, as indicating the probable limit to which the coal could be advantageously worked. Did the measures of the district everywhere preserve the moderate dip of 5 to 7 degrees, and were the seams under water accessible at all points, a line of two miles from the shore would be a truer boundary. At some points workings could be easily extended over two miles from the coast line in the upper seams, but there are places along the shore where the submarine coals are practically inaccessible, and the line marked will be found to present a fair average for the purpose of calculation. This estimate of the subaqueous coal adds to the land area at least 55 square miles; an important increase, and one that may justly be allowed, as at some points operations are in progress under the sea, and at other places, preparations are being made for undertaking similar works.

The former extent of this coal-field to the eastward is now a question beyond the reach of solution, and the conviction is forced on the mind of even the most casual observer that it is but a remnant of the measures deposited at the coal-producing period of the carboniferous era, that the rim only is left of an immense district, now lost, under the Atlantic. The progress of the denudation which has been going on for centuries is still visible, and geologically speaking, at no distant epoch in the present course of events, the Cape Breton coal-field will be totally swept away. The old French fort at Glace Bay has furnished a means of measuring the annual waste. From plans preserved in Paris, of the position of the fort at the time of its erection, it would appear that the removal of the coast has been going on at the rate of two feet every year. At other points the annual waste has not exceeded six to ten inches. Flint Island was evidently at one time part of the mainland, and the millstone grit of the Bird Islands, off Cape Dauphin, shows that the waste of the Atlantic has been equally great at that point.

In an attempt to describe subaqueous areas the question of dykes and faults becomes of great importance. The latter are quite unknown in the Cape Breton coal strata, and there is but one set of faults. These dislocations follow the general run of the bays, pursuing a general east and west course—as at Sydney, Lingan, and Cow Bay, leaving wide intervals of undisturbed coal. The exceptional freedom from faults which characterises this coal-field has been strongly dwelt upon by all who have been engaged in exploring it. Professor Lesley, in reporting on the Little Glace Bay coal-beds, says:—"The water level lines of the beds are now seen to be parallel, and the whole country wonderfully level and free from

faults." This remark applies equally to the other districts, and adds materially to the confidence with which mining operations are begun.

The only troubles of any consequence met with, are occasional lagoon or dirt beds, and in some places the tilted-up beds of brooks, causing what are locally known as "nips."

The direction of the cleat in the flatter seams may be averaged as varying within twenty degrees of a line drawn at right angles to the strike; the steeper seams have the cleat running roughly parallel to the line of strike.

The first district to be considered is the narrow neck of land forming the south side of Cow Bay. The Block House seam, the highest of this series, is considered by Professor Lesley the equivalent of the Harbour seam of Glace Bay. Its land area is 240 acres, and it is to be feared that it may not be possible to utilize its seaward extension economically. Below this seam, at a depth of 350 feet, is the McAulay bed, generally considered to represent the Phelan seam.

From the map it will appear that these uppermost seams, the Block House and McAulay, pass to the east of South Head, and are lost to the miner's reach unless won by expensive drifting. Opinions are divided whether the South Head or Wilson seam should be identified with the Spencer or McRury. As there are 50 feet of strata between the McRury and Spencer, the latter being 200 feet below the McAulay, and over 60 feet of strata exposed between the Wilson seam and the end of the Head, it is probably the Spencer seam and not the McRury, as Mr. Lyman suggests. The seams therefore underlying the Spencer bed, and best known as the Long Beach seams, are all found crossing the South Head with a regular dip to the north-east at an average angle of five degrees.

Equivalents of the Long Beach seams found on South Head :—

							Ft.	In.	
Spencer or Wilson seam	...	...	...	...	...	...	6	0	Stone parting.
McRury	...	...	...	...	...	...	4	4	
Seam	...	...	...	...	...	...	3	0	
Seam	...	...	...	...	...	...	2	0	
Long Beach seam	...	...	...	...	...	...	3	0	
Tracey seam	...	...	...	...	...	...	4	6	

Included in about 2,600 feet of strata.

This narrow strip of land has preserved the means of winning a large extent of coal otherwise lost under the sea. The seams above given, cross it successively at right angles, and a series of pits can be sunk to win these coals in a district of 12 square miles on the north side of Mira Bay,

as well as under part of Cow Bay. The quality of these coals does not appear to be quite equal to that of those found further north. Openings were made some years ago on the Wilson and Tracey beds, but were abandoned as the shipping facilities were not good. Now, however, the building of the Louisberg Railway will afford an outlet to a safe and commodious harbour.

Passing to the opposite side of Cow Bay we find the above seams, as well as the overlying McAulay and Block House seams, thrown up against the anticlinal axis of Cape Granby at angles approaching 45 degrees. A sudden bend of the coast line cuts across the northern crop of the seams just given, which then pass into the ocean on a course parallel to the line of upthrow. It is not probable that any attempts will be made for some time to win the submarine coals at this point unless in conjunction with the land areas at the point where they leave the shore.

North Head or Cape Granby has played an important part in preserving Cow Bay from being completely swept away by the Atlantic. A series of beds of very hard sandstone were brought up along the line of anticlinal, and have stood the action of the sea better than the overlying measures holding the coal seams. Had the Pictou coal strata, containing in places 500 to 1,200 feet of soft shale, without sandstone or other indurated beds, been similarly exposed, we would have had to deplore a still more serious denudation.

On crossing to Schooner Pond we find the measures lying once more at an easy angle, the dip being N. 25 degrees E. angle 7 degrees. The value of the submarine areas may now be gathered from the fact that the various seams are accessible under water from this point to Cape Dauphin, a distance of over thirty miles.

About one and a half miles from the shore of the north head of Cow Bay are two small islands containing the crop of a coal seam dipping N.E. Another seam was said to be at one time visible at low water, but the writer is unable to furnish any particulars of its size, &c. These islands were formerly, in all probability, part of the mainland, and the coal seams a continuation of part of the Glace Bay series. Their value, however, is the proof afforded of the important fact, that there are no disturbances of moment affecting the measures, now covered by water, between them and the shore.

The Schooner Pond seams are the equivalents of those already described under the various names given at the time of their discovery. The highest cropping on the shore is the Three-foot seam, underlying it at a thickness of 300 feet is the Back Pit seam, then the Phelan, 8 feet 3

inches, and the Ross 5 feet. All these seams can be attacked and followed under the sea as is being done at the Schooner Pond Colliery. Below these seams and within workable distance are the Gardner, Lorway, and other less developed seams. No obstruction can be foreseen to prevent workings being carried to any practicable distance from the shore at this point.

The seams run parallel to the shore till the north side of Glace Bay Lake is reached, when the coast line takes a turn to the north, and exposes the crops of two overlying seams. These seams, known as the Harbour and Hub coals, are respectively 243 and 763 feet above the Three-foot seam of Schooner Pond.

Professor Lesley, in his careful and elaborate survey of Glace and Cow Bays, states the equivalence of the latter to the Block House seam. Its form therefore would be that of a horse-shoe passing to the east of Cape Granby, and entering the land again near the mouth of Little Glace Bay Brook. Its land area here is 2,000 acres, containing 16,000,000 tons of coal; the sea area of accessible coal is about one-half larger.

The Hub seam overlies this 520 feet, and is considered, as its name implies, the highest known coal seam of Eastern Cape Breton. Its excellent quality and superior mining facilities render its comparatively small area a matter of much regret. Its accessible sea area may be estimated at 2,500 acres, yielding 35,000,000 tons. Both these seams are within reach of a shaft of moderate depth at Table Head. The opposing sweeps of the coast line and of the strikes of the strata afford unusual mining advantages, it being possible to drive levels from the pit bottom, giving rise coal on each side of the shaft.

Beneath the Harbour seam, the Three-foot, Back Pit, Phelan, Ross, and McRury seams successively basset on the shore of Indian Bay, with a general strike a little to the east of north, and with an average inclination of five degrees, which uniformity is preserved from this point to the shore of Glace Bay Lake.

Lingan Basin, again, is underlaid at workable depths by the Lorway, Gardner, and less known seams, and at no distant date the operations of companies working on the shore will be extended under it.

On the north shore of Lingan Basin is an anticlinal fault, similar to that mentioned as occurring in Cow Bay, and producing an almost identical effect on the measures, so that an interval is formed in which the seams appear inaccessible. The district lying to the eastward of a line drawn from a point near the head of Lingan Basin to McPhee's Ferry on Sydney Harbour belongs to the General Mining Association, and is not

yet well known, mining operations having been confined to the seams on the shore.

The Lingan Main seam is generally considered the equivalent of the Phelan, as worked to the south. The Mining Association also holds two sea areas, each containing five square miles, and extending from North Head to Low Point. The thickness of the main seam is 8 feet 8 inches. Workings have been extended under part of these areas, which yield, to use the words of Mr. Brown, late manager, "a quantity of coal practically illimitable." Above this seam are five others, cropping on the shore and running under the sea at angles averaging ten degrees. At the Barrasois this company has driven a slope under the sea on an 8 foot 8 inch seam, for a distance of 120 yards. Work is, however, suspended at present. The following is a section of the Lingan series (Plate XXXV.) :—

					Ft. In.		Ft. In.
Carr's seam	...	...	...	...	4 0	...	—
„ strata	...	...	...	...	—	...	220 0
Barrasois seam	...	...	...	...	8 8	...	—
„ strata	...	...	...	...	—	...	54 0
Dunphy's seam	...	...	...	...	4 0	...	—
„ strata	...	...	...	...	—	...	81 0
David's seam	...	...	...	...	7 0	...	—
„ strata	...	...	...	...	—	...	240 0
North Head seam	...	...	...	...	3 0	...	—
„ strata	...	...	...	...	—	...	82 0
Lingan Main seam	...	...	..	..	8 8	...	—

There are several seams below this section, but their position is not well ascertained. The lowest is found three miles to the west of the crop of the Main seam. The value of this district will be gathered from Mr. Brown's estimates, given further on.

The above series of seams pass to the west of Low Point, and crop again on the south shore of Sydney harbour, where within a width not exceeding one mile measured across the strike, all the coal seams of the district crop with a dip to the north at angles varying from thirty to forty degrees. This locality has been fully described by Dr. Dawson, and a summary of his report is given in Mr. Rutherford's paper. An area of four square miles has been acquired to cover the subaqueous extension of these seams. At least six of them, representing thirty-six feet of coal, are of good quality and of workable size. The breadth of the area is such that with their high dip all the coal that could be extracted from these seams will be included within the area.

The seams of the southern part of the coal-field having been noticed

as regards the feasibility of their being worked under the sea, that part of the district extending from Sydney Harbour to Cape Dauphin remains to be described. The General Mining Association owns the greater part of this section, their land area being 11,700 acres; they hold also a sea area of 3,200 acres at Craneberry Head, now being worked for the main seam. The seams of workable size found on the north side of Sydney Harbour, are four in number, namely, the

							Ft.	In.
Lloyd's Cove seam	...	...	...	...	...	...	6	0
Sydney Main „	...	...	...	...	...	...	6	0
Indian Cove „	...	...	...	...	...	...	4	8
Stoney „	...	...	...	...	...	...	3	8

Included in 1,860 feet of strata.

These seams can be traced to the Little Bras D'or, and are found to increase in thickness as they go to the north. Mr. Brown, who had charge of the Sydney Collieries for many years, considered the Mill Pond seam the equivalent of the main seam. Professor Hynd, however, in his report on the Point Aconi submarine area in 1872, proved the presence of a fault following the course of the Little Bras D'or, which throws the main seam 400 feet up into the position on Bouladrie Island, marked on the plan. This upthrow, while considerably diminishing the land area of the seam in this locality, adds to its accessibility for subaqueous working.

This valuable seam, highly esteemed for domestic use in Nova Scotia and Canada, is therefore accessible at all points of the shore from Sydney Harbour to the Big Bras D'or. At this point there are found below the main seam—

				Ft.	In.		Ft.	In.
The Crawley seam	...	...	...	7	6	...	—	
„ strata	...	...	...	—		...	560	0
Mill Pond seam	...	...	...	4	0	...	—	
„ strata...	...	...	...	—		...	400	0
Black Rock seam	...	...	...	4	0	...	—	

These seams have not been worked to any extent, their size and quality being known chiefly from trial pits confined to their crops.

Crossing the Big Bras D'or the coal seams of Campbellton remain to be noticed. Two seams are known here, covering an area of about one and a half square miles. The dip at the Bras D'or is to the east at an angle of 12 degrees, but rapidly becomes almost vertical, owing to the protrusion of the syenitic ridge of Cape Dauphin. The effect of this disturbance can be traced out to sea in the Bird Rocks, which are evidently on the axis of an anticlinal pursuing a course parallel to those of Lingan and Cow Bay. The reverse or northerly dip is shown by the presence of carboniferous strata at St. Ann's Harbour.

At Inganish and Astry Bay are found similar patches of carboniferous strata, just enough being left to prove the immense extent of these measures at a former period, and the wonderful denudation which, in Cape Breton, has almost completely stripped the carboniferous from the underlying silurian and older rocks.

SUBMARINE COAL OF WESTERN CAPE BRETON.

In this connection the coal-field of Western Cape Breton claims attention. The law requiring reports of the work done by lessees of the Crown not having been always complied with, details of coal seams, their size, position, etc., cannot be easily obtained. The present dulness in the American coal trade has tended during the past few years to discourage exploration, and to prevent the investing of large amounts of capital in coal mining. Mr. Rutherford's summary in his paper on the Coal-fields of Nova Scotia, gives a good idea of the district as known at that time. In order that the continuity of this paper may be maintained it is proposed to give a brief description of the coal-measures of this part of the island, and include the latest discoveries.

An idea of the district may be formed by imagining a large coal-field with a gentle dip to the west, folded in repeated undulations, running east and west, and then the crowns of the anticlinals denuded with great part of the intervening coals. This represents the present condition of the seams; their strike is either parallel to the shore with westerly dips under the Gulf of St. Lawrence, or they are found with north and south dips on the sides of small synclinals running out at no great distance inland.

The district lying between Mabou and the Bras D'or is occupied by carboniferous measures, and quite recently there have been statements of workable coal being found there. Should this prove true, still more important discoveries may be looked for.

At Port Hood the highest known seam crops on the beach with a dip W. angle 20 degrees. Below this, at a vertical depth of 360 feet, is another seam, six feet thick, extending about two miles along the shore. Below this are found two others, one three feet thick, and another of workable size, of which the writer has no particulars.

At Mabou another series of seams is found in a synclinal form, occupying a basin one mile wide, and somewhat longer, from east to west. The relative positions of the seams in the series are—

										Ft.	In.
1st seam	...	...	...	...	...	...	...	...	...	5	0
2nd „	...	...	...	...	...	...	...	...	...	7	0
3rd „	...	...	...	...	...	...	...	...	...	13	0
4th „	...	...	...	...	...	...	...	...	...	4	0

Included in 500 feet of strata, both north and south crops being known.

The reverse pitch of the north crop is exposed a little distance to the northward. From this point the seams are known to range for some distance along the shore with seaward dips, but no detailed examinations have yet been systematically carried out.

At Broad Cove Professor Hynd divided the seams into two groups, the lower containing two seams, one two feet six inches thick, and one 60 feet lower, of which no details are known. Within a few weeks the crop of a 16 feet seam has been found underlying these, at a vertical depth of 100 feet. The upper group contains—

							Ft. In.		Ft. In.
Coal	...	...	...	...	...	...	3 0	...	—
Strata	...	...	...	...	...	...	—	...	340 0
Coal	...	...	...	...	...	...	5 0	...	—
Strata	...	...	...	...	...	...	—	...	100 0
Coal	...	...	...	...	...	...	7 0	...	—
Strata	...	...	...	...	...	...	—	...	240 0
Coal	...	...	...	...	...	...	3 6	...	—

These seams are found in a similar synclinal form to those at Mabou. Their range inland is much more extensive, and it is believed that this district will shortly prove very valuable.

This group can be traced as far as Chimney Corner, about ten miles to the north. At this place the lower group contains several seams, but no work has been done to settle their size.

The upper group gives the following section :—

							Ft. In.		Ft. In.
Coal	...	...	...	...	...	...	1 6	...	—
Strata	...	...	...	...	...	...	—	...	300 0
Coal	...	...	...	...	...	...	3 0	...	—
Strata	...	...	...	...	...	...	—	...	88 0
Coal	...	...	...	...	...	...	5 0	...	—
Strata	...	...	...	...	...	...	—	...	200 4
Coal	...	...	...	...	...	...	3 6	...	—
Strata	...	...	...	...	...	...	—	...	—
Large coal seam	...	...	...	...	...	...	—	...	—

There are no details of the lowest bed, operations having been confined to the 3 feet 6 inch seam.

The similarity between the Broad Cove and Chimney Corner seams is very striking, and points to the identity of the 5 feet seam of the latter place with the 7 feet of the former. At Chimney Corner a colliery was opened on the 3 feet 6 inch seam, which dips north-west, at an angle of 40 degrees, but is closed at present. The slope was started in what appeared at first to be almost dangerous proximity to the shore, but the measures, consisting of massive bedded sandstones, proved perfectly

impermeable to water. The quality of this coal was considered admirably adapted for steam purposes, and a small quantity has been shipped.

Until careful and connected surveys have been made, it is difficult to give any estimate of the amount of accessible coal lying under the sea. There can be no doubt, however, that there is an immense amount, and that at some future date very valuable sea areas will be worked on this side of the island.

The great drawback is the absence of any suitable harbour on this coast within easy reach of the coal. The carboniferous measures are rapidly wasting in consequence of the prevailing westerly winds which have the full breadth of the Gulf of St. Lawrence to sweep across. These winds, aided by the tides, choke the rivers and harbours with sand bars which are continually shifting, and render navigation unpleasant. Professor Dawson, in his *Acadian Geology*, gives the following instance of this:—"Owing to the waste of the coast, a sand bar, which connected Port Hood Island with the mainland, has been swept away, and a safe harbour has thus been converted into an open roadstead, exposed to northerly winds, and encumbered with shoals. This will prove a serious drawback to any attempt to work the coal-beds of this locality."

The following estimates collected from the reports of various engineers show what an immense amount of coal is accessible outside of what are usually called the limits of the Cape Breton Coal-field.

The average specific gravity of the Cape Breton coals may be taken at 1.3. The ordinary formula based upon this gives 1,580 tons as the weight of an acre of coals one foot thick, the Nova Scotia coal ton containing 2,240 lbs. In the following estimates the round number 1,500 is taken.

At the Schooner Pond area the only seam opened is the Ross, 6 feet thick, underlying, in addition to the land area, a sea area of 640 acres, in which are contained 5,850,000 tons. In addition to this, however, the whole of the submarine area is underlaid, probably under workable conditions, by the Great Phelan seam; and both land and sea areas by the Lorway, Gardner, and other less developed seams.

SWORD PROPERTY—GLACE BAY.

This area, containing 2,250 acres, is more or less underlaid by four workable seams, yielding—

				Acres.		Tons of Coal.
The Hub Seam	...	...	9 ft. 6 in.	798	...	11,371,500
„ Harbour „	...	...	5 ft. 6 in.	1,466	...	12,094,500
„ Black Pit „	...	...	4 ft. 6 in.	1,782	...	12,028,500
„ Phelan „	...	...	8 ft. 8 in.	2,215	...	27,576,750
Total				...	...	63,071,250

VICTORIA SUBMARINE AREA.

The Ross seam only has been opened here ; its thickness is 5 feet 6 inches. The quantity of coal within the area in this seam to a depth of 4,000 feet is 15,500,000 tons. The total amount of coal in this area, calculated from the six workable seams, proved above and below the Ross bed, cannot be less than 90,000,000 tons.

THE POINT ACONI PROPERTY

Contains over 20,000,000 tons of the Sydney main seam coal, according to Professor Hynd, who was for some time engaged in a geological examination of the locality, and according to his calculations would be underlaid at that spot by

							Ft.	In.
The Sydney main seam	...	...	...	...	...	...	6	0
„ Crawley	„	...	...	...	...	...	7	6
„ Mill Pond (formerly considered the Sydney main seam)							4	0
„ Black Rock seam	...	...	...	...	...	...	4	0
Contained within 1,180 feet of strata.								

Professor Hynd also estimates the quantity of main seam coal in the (New) Sydney Colliery to be 91,000,000 tons.

The following are Mr. Brown's estimates :—

CRANEBERRY HEAD AREA (SUBMARINE.)

				Acres.		Tons.
In the Lloyd's Cove seam	...	...	...	1,650	...	14,950,000
„ Main	„	...	...	3,200	...	28,800,000
„ Indian Cove	„	...	...	3,200	...	22,400,000
Tons						66,150,000

1ST LINGAN SEA AREA.—5 SQUARE MILES.

			Acres.	Thickness.	Tons.
The Carr seam	...	...	3,100	4 0	18,600,000
Barrasois	„	...	3,170	8 8	41,210,000
Dunphy	„	...	3,200	4 0	19,200,000
David	„	...	—	7 0	33,600,000
Main	„	...	—	8 8	41,600,000
					154,210,000

2ND LINGAN SEA AREA.—5 SQUARE MILES.

The Carr, Barrasois, and other seams, yield, according to the same authority, no less than 141,895,000 tons of coal of good quality.

NATURE OF STRATA.

The measures enclosing the Cape Breton coals are largely composed of sandstones, frequently occurring in massive beds, sometimes intercalated

with shales and thin girdles of ironstone. A few beds of limestone and conglomerate are met, but their thickness is insignificant. The layers of ironstone balls vary in thickness from two inches to three feet; the quality is reported to be sometimes suitable for iron making, but, as far as the writer is aware, no practical tests have been made. The following is a summary of the measures between the Back Pit and Phelan seams.

								Ft.	In.
Sandstone ...	...	...	...	...	...	...	...	91	1
Shales—Fireclay ...	...	...	...	...	...	...	...	17	4
Ironstone—Coal ...	...	...	...	...	...	...	...	2	6
								110	11

This may be taken as an average of the proportions of the various strata of the Glace Bay district.

The section of the north side of Sydney Harbour contains a much larger percentage of fire-clay and shales.

Summary of measures overlying the Sydney main seam :—

								Ft.	In.
Lloyd's Cove seam	...	...	...	...	...	...	...	5	0
Sandstones and shales	...	...	...	...	...	...	...	209	0
Sandstone ...	...	...	...	...	...	...	...	41	0
Shales	...	...	...	...	...	...	...	37	0
Sandstone ...	...	...	...	...	...	...	...	31	0
Shales and sandstones	...	...	...	...	...	...	...	142	0
Sandstone ...	...	...	...	...	...	...	...	47	0
Shales and sandstones	...	...	...	...	...	...	...	97	0
Sandstone ...	...	...	...	...	...	...	...	21	0
Shales	...	...	...	...	...	...	...	72	0
Sandstone	...	...	...	...	...	...	...	24	0
Shale, 2-6 feet	...	...	...	...	...	...	...	—
Main seam	...	...	...	...	...	...	...	6	0

The beds of sandstone are very firm and massive. The shales and sandstones are in alternating layers from 2 inches to 10 feet in thickness—the result of the workings in the main seam being that the roof is very easily managed. The shales are to a great extent arenaceous, few being bituminous.

SYSTEMS OF WORKING.—SYDNEY COLLIERY.

The bord and pillar system is the one employed at this mine, both in the land and sea areas. Until the completion of the new winnings the dip coal is drawn to the bottom of the Queen Pit by two inclines, each over 1,000 yards long, 7 feet wide, and 6 feet high. These inclines are driven nearly on the full dip of the coal, which is N. 60 degrees E. at an angle of 4 degrees 45', or one in twelve; one supplies the northern and the other

the southern section of the workings. They are laid with suitable tracks of two feet gauge, with wrought iron rails weighing 32 lbs. to the yard. The tubs hold 10 cwts each, and twenty form the usual load.

From the inclines, main levels or way-gates are turned 6 feet wide and 5 feet high, and laid with rails similar to those in the inclines. Gate-roads or headways 6 feet wide are driven from the main level at regular intervals of 40 yards obliquely to the rise, at about 20 degrees off the full pitch of the seam. At every 14 yards the bords are broken off 16½ feet wide, and driven parallel to the main level, leaving pillars 40 yards long by 14 yards wide. The coal is mined by holing in the bottom and nicking one side, the fall and bench being taken out by wedge or powder. The proportion of slack is one-fifth, and is generally left in the mine. The coal is banked out during the suspension of navigation in winter, and is found to contain twenty-five per cent. of slack on being lifted again. The submarine workings are being pushed north and south from Craneberry Head, with 480 feet of cover between them and the sea bottom. No pillars have yet been drawn under the sea, although there is every reason to believe that the unusual firmness of the overlying strata would permit of a much smaller scale of pillarage.

VICTORIA COAL MINES.

This colliery is nearly opposite Sydney, on the south side of the harbour. At this point the seams dip N. 30 degrees W., angle 38 degrees 30'. The seam worked is 6 feet thick, with roof and floor of unusually good description, 6 inches of bottom coal are left, being of inferior quality.

The submarine coal is won by a slope 300 yards long, 15 feet wide, and 9 feet high, beginning about 60 yards from the shore, and driven on the full pitch of the seam, with parallel smaller slopes for ventilation. There are three main levels driven 8 feet wide, and the full height of the seam. The bords are turned to the rise, and continued from level to level, forming pillars 23 yards long and 8 yards wide. The coal is run to the lowest level either by its gravity or by means of counter-balances similar to those described by the writer in a former paper on the Pictou Coal-field. This lowest level is laid with a permanent track of 2 feet gauge, on which the tubs, of one ton capacity, are drawn to the slope by horses. On arriving at the slope, which is laid with a double 4 feet 6 inch gauge track, two tubs are pushed on to a platform with four wheels, on the nearest track, and made horizontal by having the diameter of the upper pair of wheels much smaller than that of the lower pair, and drawn to bank by a wire rope of 1¼ inch diameter. The engines are of 120 horse-power, having two 22 inch

cylinders, 4 feet 6 inches stroke, working direct on drums 10 feet in diameter. These arrangements are equal to a daily output of 500 tons.

A pump working at the rate of 40 gallons per minute drains the mine in twelve hours, most of the water being from the surface and old workings.

LINGAN.

The submarine workings at this colliery are pursued on a similar system to that in use at Sydney. The coal is worked through a slope 8 feet wide and 700 yards long, driven on the pitch of the seam, and drawn by a high pressure engine of 40 horse-power stationed at bank. The pillars are 22 yards long and 5 yards wide ; the working places 15 and 18 feet wide, are turned to suit the cleat of the coal. Although workings have been extended a considerable distance under the sea, there is but a trifling amount of water made, the accumulation not exceeding one ton per day.

At Schooner Pond similar arrangements are in progress for working under the sea.

GAS AND VENTILATION.

The early workings in the Cape Breton coals being confined to the vicinity of the crop, trifling amounts of gas were met, and the ventilating appliances were of the simplest description. It is found that gas increases considerably as workings go to the dip ; as yet, however, safety-lamps are carried only by firemen. The ventilation at all these collieries worked by slopes is through furnaces generally placed near the crop, and provided with high wooden stacks. The amounts of air passed in the above-mentioned collieries vary from 20,000 to 30,000 cubic feet per minute. No mechanical ventilators are used in Cape Breton, the only one at present in the province being a 30 feet Guibal fan at the Albion Colliery, Pictou.

SHIPPING FACILITIES.

Some of the Cape Breton collieries have artificial shipping places, the remainder ship at Sydney Harbour. Among the latter are the Sydney, Victoria, International, and Reserve Mines. The Lingan, Little Glacey Bay, Caledonia, Block House, and Gowrie, have constructed independent loading grounds, connected by short railways, with their works. The Block House and Gowrie ship at open wharves in Cow Bay protected by a breakwater. These structures are very expensive, being necessarily of great strength to resist the sweep of the ice and the Atlantic gales.

At Glace Bay, Caledonia, and Lingan, docks have been excavated at the mouths of brooks or land-locked lagoons. These places are small,

frequently inconvenient of access, and require, moreover, a constant expenditure for dredging and repairs.

The following description of the shipping place of the Caledonia Colliery will show their usual character :—"Port Caledonia is formed by an artificial cut at the corner of Glace Bay and Lake, with piers of crib work loaded with stone, 80 feet apart at the mouth, and 120 feet at the wharf or shipping place, and extending 400 yards from the wharf into the sea. The wharf is provided with three shipping places, two loading shoots, and a steam crane, and is capable of accommodating vessels drawing up to 17 feet of water. A small propeller tug of 45 horse power, and a steam dredge of about the same power, are employed in connection with this harbour."

These independent little shipping places have each a complement of wharfinen, tugs, dredges, etc., besides a railway for each colliery ; all these things unite as a great source of expense. In addition to this, all the present wharves are virtually closed during the winter months.

When there can be no coal shipped, each colliery banks out the coal that is extracted, or lessens the number of men employed. This bank coal is exposed to the alternate snow and rain, storms and frosts which characterize the winter in the Lower Province, and when raised in summer is found to have formed a proportion of slack, sometimes exceeding one-fourth of the original amount.

In regard to the alteration of coal by prolonged exposure to moist air, M. Vanenstrass finds that the loss of weight due to slow oxidation and to the escape of gases rich in carbon may amount to one-third of the original weight. The calorific power sustains in this case a loss of 47 per cent. He finds that in closed storehouses the loss of heating power is less than 10 per cent. ; bituminous coals of the varieties most generally found in Europe undergoing the most rapid alterations.

This remark applies with even more force to the bituminous coals of Cape Breton, which are exposed to more rapid and extreme changes of temperature, and to a climate containing an equal amount of moisture. The slack coal is frequently made from the more tender and bituminous part of the seam and the reputation of the coal made to depend on the inferior parts of the bed.

When shipping is resumed this bank coal is sent away mixed in various proportions with the fresh coals. No comment is needed on the effect produced on the market price of the coal by the addition of such a deteriorated material. It is to be hoped that the completion of the Louisburg and Cape Breton Railway from Sydney to Louisburg will introduce

a more satisfactory state of affairs, and that the collieries generally will avail themselves of the chance of avoiding the unfavourable conditions stated above.

Louisburg Harbour is one of the finest of the many good ports of Nova Scotia. During the present winter, one of unparalleled severity, when New York, Baltimore, and even Halifax Harbour, were blockaded by ice, there was not one day in which coal shipping could not be carried on at Louisburg. This harbour, during the early history of the colony, was selected by the French as their naval head-quarters in North America, and has frequently held their flotillas for weeks in perfect safety. The more inland collieries, such as the Lorway, Gardner, and Reserve, will be directly benefited by the extension to Louisburg, as they will be enabled to ship fresh coal during the whole year, and to effect what is very seldom attained in Nova Scotia under the present state of affairs, namely, working full time during the winter months.

THE FOLLOWING ARE THE REGULATIONS AS TO WORKING
SUBMARINE AREAS IN NOVA SCOTIA :—

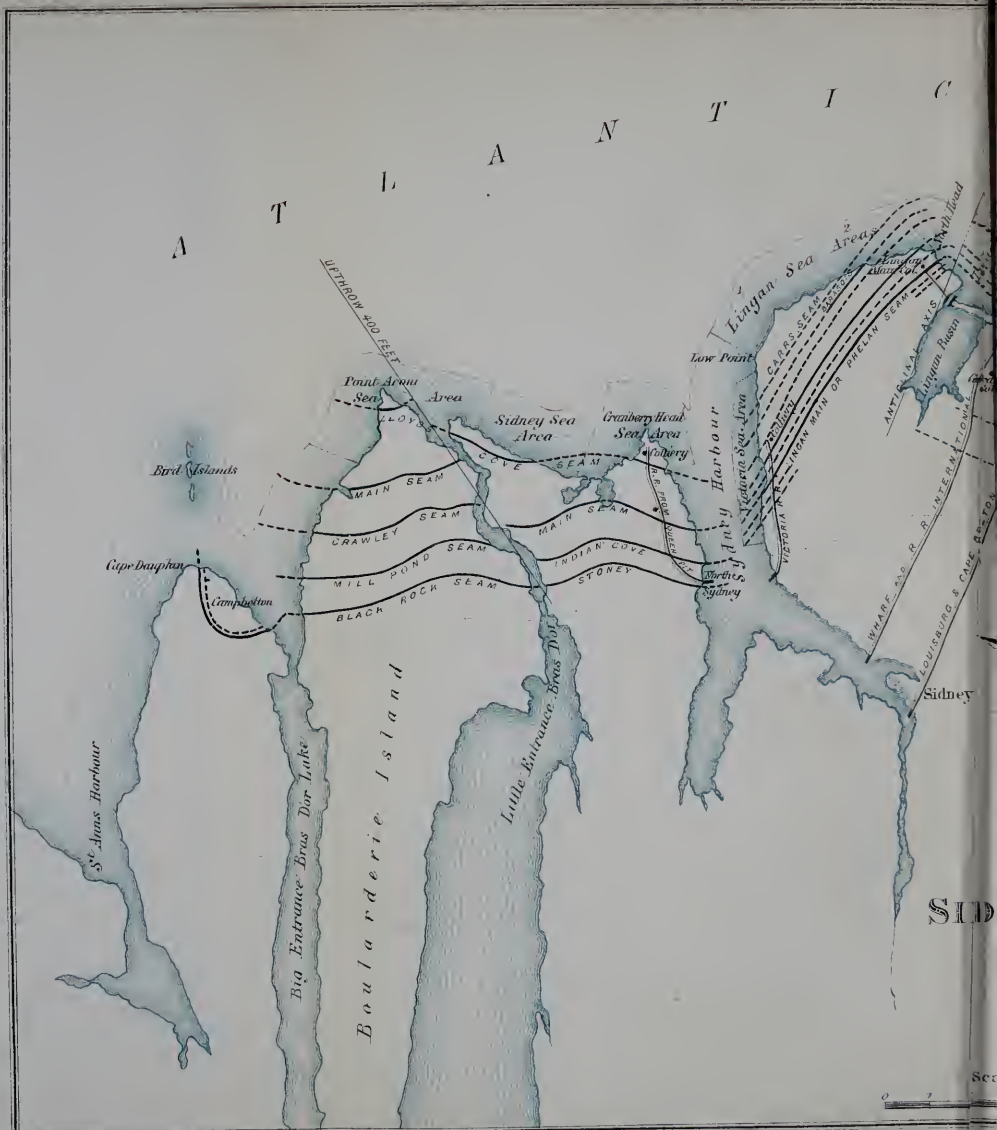
1.—No coal shall be wrought under a less cover than 180 feet of solid measures, provided that the owner or lessee of such area may drive passage-ways to win coal under less cover than 180 feet, but not under less than 100 feet of solid measures.

2.—A barrier of not less than 150 feet must be left unwrought between the boundary lines of every lease in the workings of every submarine seam.

3.—The working of every such submarine area shall be laid off in districts of an area not greater than half of one square mile, and the barrier enclosing each separate district shall not be less than 30 yards thick, and shall not be pierced by more than three passage-ways, having a sectional area not greater than six feet by six feet.

4.—No district shall have its length, when parallel to the general trend of the adjoining shore, greater than one mile.

5.—A proposed system of working the coal in each submarine area shall, before work is commenced, be submitted to and approved of by the Inspector; and no change shall be made in such approved system without the written sanction of the Inspector. The opening of a new level or lift in a mine already working in a submarine area shall be deemed the commencement of a new winning in the meaning of this clause. The penalty to be inflicted for transgression of the above regulations is 1,000 dollars, or £200 sterling; if the offence be continued, the works may be stopped by order of the Government.



SECTION OF THE CAPE BRETON COAL MEASURES.

FROM REPORTS OF DRS. DAWSON, LESLEY, AND OTHERS.

	Strata. Ft.	Coal. In.
Hub seam. Not found except at Table head	—	9 9
	20 0	—
Cannel coal	—	2 0
Strata containing thin seams of Cannel coal	480 0	—
Harbour seam. Supposed Block House seam of Cow Bay	—	5 6
	247 0	—
Brutheters seam	—	2 0
	82 0	—
Black Pit seam	—	4 6
	100 0	—
Phelan seam; known also as the Lingan Main and McAulay	—	8 3
	210 0	—
Ross seam of Cow Bay and Glace Bay, Wilson seam of South Head	—	—
	58 0	—
McRury	—	4 4
	100 0	—
Coal seam	—	3 0
	50 0	—
Coal seam	—	2 0
	200 0	—
Long Beach seam	—	3 0
	50 0	—
Coal seam	—	2 3
	209 0	—
Coal seam	—	6 0
	330 0	—
Gardner seam	—	4 9
	35 0	—
Coal seam	—	4 0
	600 0	—
Cannel seam	—	6 0
Coal seam	1000 0	—

From this table the various equivalent seams may be collated. The total thickness of the coal formation is variously estimated.

The Sydney seams are supposed to be represented by the lowest beds known at Mira Bay. There is, however, much doubt that any seam can be traced from end to end of the coal-field, the present theories presenting many difficulties. It is to be hoped that the labours of the Geological Survey of Canada will be able to settle this very important point.

The following paper, by Mr. Wm. Routledge, "On the Sydney Coal-Field in the Island of Cape Breton, British North America," was considered as read, and ordered to be printed.

NOTES ON THE SYDNEY COAL-FIELD IN THE ISLAND OF
CAPE BRETON, BRITISH NORTH AMERICA.

BY WM. ROUTLEDGE, M.E., SYDNEY, C.B.

THERE is probably no part of the British Empire that contains such a vast extent of coal formation in proportion to its size, as the Island of Cape Breton, in British North America. Situated at the mouth of the Saint Lawrence, the northern shore of this island forms the southern shores of the Saint Lawrence ; to the west this island is cut off from Nova Scotia proper by the Straits of Canso, an important navigable channel connecting the Atlantic with the Bay of Saint Lawrence. The southern and eastern shores of this island are bounded by the Atlantic Ocean. In looking over the geological map of Cape Breton there will be found no less than four coal districts, one of which, the Sydney Coal District, on the eastern shores of Cape Breton, is of very considerable extent. The land area occupied by the productive coal measures in the eastern or Sydney coal-field may, so far as is now known, be estimated at 200 square miles, being about 32 miles in length from the mouth of Big Bras D'or, on the north-west, to Mira Bay, on the south-east, by about six miles in width. It is limited to the east by the Atlantic Ocean, and towards the west by the outcrop of the underlying lower carboniferous rocks. The land area of the Sydney coal-field forms the western margin of troughs or basins of coal, which are for the most part hidden under the waters of the Atlantic Ocean. The whole coast is deeply indented by bays and rivers, affording in the rocky cliffs numerous natural sections of the strata and exposures of the coal seams. Some of these bays also constitute excellent harbours ; first among which stands Sydney Harbour, which ranks among the finest and most commodious on the Atlantic coast. Other harbours are also on the coast which afford considerable facilities for the ready shipment of coals at a short distance from the mines of production. Lunenburg, Glace Bay, Port Caledonia, and Cow Bay, are not in any case more than two miles from the working collieries ; such natural advantages, combined

with its highly-favoured geographical position, point to the Sydney coal-field as probably the most important in the Dominion of Canada for the supply of fuel to the numerous steam-ships crossing the Atlantic. Cape Breton being as it were the key to the Saint Lawrence, steamers from Montreal and Quebec to Europe, with slight deviation from their usual course, could call at Sydney for coals. Sailing vessels from Europe, bound up the Saint Lawrence in ballast, are always sure of a cargo at good rates up to Quebec and Montreal from Sydney and outports, without at all going out of their usual course ; and with the extension of the railway system to the old harbour of Louisburgh, it is expected that during the winter months, when most of the harbours are closed by ice, steamers will be able to coal at Louisburgh. Opinions differ as to the possibility of steamers coming so far north in winter, but there is no doubt when some enterprising steam-ship company sets an example by using the port, it will be found of great convenience, for steamers can purchase coal there, on this side of the Atlantic, at a much cheaper rate than at Halifax.

The aggregate thickness of coal in workable seams in the several basins (hereafter named) in the Sydney coal-field is from 25 to 60 feet, and as a rule the seams dip at a low angle, and, so far as is known, are not affected by faults or dykes ; as all the strata dip seaward, much of the coal will be available in the submarine as well as in the land areas.

The seams of coal in this coal-field are of the bituminous or soft variety, all of which yield a coal well adapted for general purposes, while the produce of some of them is specially applicable for the manufacture of gas. Much of the mineral will compare very favourably with the best English coals.

Although, as before said, the Island of Cape Breton possesses considerable area of coal-bearing strata, very little has been done beyond explorations, except in the Eastern or Sydney coal-field, in which there have been a number of first-class mines or collieries opened out, fully proving the extent of the coal-field, and also the approximate depth of the coal measures.

From explorations and the opening out of collieries in the Sydney coal-field it would seem as if it were divided into four different and distinct coal basins or troughs. See Plate XXXVI.

No. 1, extending from the mouth of Big Bras D'or River southward, a distance of eight miles, to Sydney River, and comprising what is generally known as the Sydney Mines section.

Basin No. 2, extending from Sydney River south, about five miles to the shore of Lingan Bay, and usually termed the Lingan tract.

Basin No. 3, extending from the southern shore of Lingan Bay, a

distance of about eleven miles southward to the northern head of Cow Bay, and generally known as the Glace Bay section.

Basin No. 4, extending from a point marked N on the map, about four miles westwardly inland, from the shore of Cow Bay, and southwardly under the waters of Cow Bay, called the Block House section.

On reference to the plan, map, and section, it will be seen that the several basins comprising the Sydney coal-field are entirely different one from another in the line of coal crops, thickness of seams, angle of dip, thickness of strata between coal seams, number of seams, and depth of coal measures. The only similarity is that all the coal seams have fire clay floors or thills, which it is well known is usual in all seams of coal.

No. 1 Basin, as will be seen from the section, Plate XXXV., contains four valuable seams of coal and a number of other smaller ones lying at an easy angle of about seven degrees. The coal seams in this basin are much thicker southward on Sydney River than to the north on Bras D'or, but from openings that have been made, the quality of the coal remains uniformly the same. The southern termination of this basin is generally supposed to be about the middle of Sydney River, the seams of coal being broken off by what may be termed a submarine anticlinal, known as Petrie's Ledges, a dangerous reef of rocks running nearly the same course as the river.

On referring to the section of strata (on line A B) this basin will be found underlayed by the following important seams in descending order :—

				Feet. In.	
No. 1	Seam	21 feet down	Cranberry Head seam	...	4 0
2	„	302	„ Lloyd's Cove seam	...	6 0
3	„	665	„ Chapel Point seam	...	2 0
4	„	1,030	„ Sydney Main seam	...	6 0
5	„	1,500	„ Indian Cove seam	...	4 8
6	„	1,690	„ Shaley seam	...	3 0
Total thickness of workable seams				...	25 8

With the exception of Chapel Point seam and Shaley seam, all the seams in this section or basin have been worked to some extent ; the main seam at the Sydney Mines has been worked for more than forty years, and is considered the best domestic coal ; at all events, in spite of severe competition, this coal maintains the highest selling price in the island. Lloyd's Cove seam has been partially worked by the owners of Sydney Mine, but operations ceased in this seam about nine years ago, owing to the company being able to supply all the demands from one pit. This seam has a stone-band about two feet from the top, which does not seri-

ously damage the character of the coal. The Indian Cove seam has also been worked in this district by the General Mining Association of London (owners of the Sydney and Lingan Mines) at their No. 3 Pit at Sydney Mines, on Ingraham's coal area, on the Bras D'or road, and by parties owning mining areas on Little Bras D'or River, but owing to the character of the coal not being such as to bring a paying price in the various home and foreign markets, all workings on this seam have been abandoned, except by the farmers for home consumption. The only colliery at present working on this section is the Pioneer Colliery of Cape Breton Sydney Mine.

On crossing over Sydney River to the south, No. 2 Coal Basin, or section on the Lingan tract, is reached; it extends southwards from the southern shore of Sydney River, a distance of five miles, to the northern head of Lingan Bay, and is underlaid by valuable seams of coal, only one of which is under three feet thick. The angle of dip in this basin is very peculiar. At the Lingan or southern end the seams lie at an angle of 12 degrees; whereas at the northern end on Sydney River the angle increases to 45 degrees. Speculators and others interested endeavour to make out and identify this basin or tract with No. 1 or Sydney Mines section, but taking into consideration the great disparity in the number of the seams, the difference in the quality of the coal, and the great angle at which the coal lies at the northern end of this basin at Victoria Mines, and the different thickness of the coal measures, complete identification seems impossible. From the extreme angle of the Victoria slope and the distance driven down (about 1,000 feet) it would place the workings at the Victoria Mines much lower than any point reached at the Sydney Mines on the opposite side of the river. Moreover, the course of the coal crop on the south side of the river is almost at right angles to that on the north.

The following undermentioned seams in descending order will be found in this basin or section on the line C D. See Plates XXXV. and XXXVI. :—

					Feet. In.	
No. 1 seam,	30 feet down,	Carr's seam	...	...	4	0
2	260	Barrasois seam	...	...	8	0
3	300	Dunphy's seam	...	...	4	0
4	360	Davy's Head seam	...	...	7	0
5	650	Northern Head seam	...	...	3	0
6	700	Lingan Main seam	...	...	8	6
7	750	Laffin's seam	...	...	2	8
8	860	Small seam	...	...	2	3
Total thickness of coal					39	5

All the above seams have been proved to some extent by the farmers and

fishermen on the shores of Sydney River and Lingan Bay. The Lingan Main seam has been worked to a great extent by the General Mining Association of London, at their Lingan Mines, and is found to be an excellent gas coal. In this seam workings are extended under the sea for some distance, where the coal seems of its usual good character. Three feet from the top of the Lingan Main seam, where it is exposed in the cliff on the northern side of Lingan Bay, there is a stone band one inch in thickness. This band continues to increase in thickness until about 1,000 yards from the shore (on water level line) to north-west, where the seam is divided by a band 14 feet thick, from which point the band gradually decreases till the seam nearly becomes united again. The Ross or Davy's Head seam is being extensively worked by the Victoria Coal Company at the Victoria Mines on the southern bank of Sydney River. The coal from this seam is largely used for domestic purposes, and is much appreciated in the various markets. The Barrasois seam, cropping out at the surface, about half-way between Lingan and Victoria Mines, has been proved by a slope by the General Mining Association. As no sales of any moment have been made from this seam, the character of the coal is not known, but from appearance it will probably prove a good domestic or house coal. So far as the slope has gone down the dip is very slight, and not in any way approaching the amount of dip at the Lingan or Victoria Mines.

At the southern or Lingan end of this basin or tract is the anticlinal I K, which, without doubt, terminates this basin. The thickness of coal measures proved is about 1,000 feet. On the other side of Lingan Bay to the south, is Basin No. 3, which is the largest in extent, and contains the greatest number of coal seams and the greatest depth of coal measures. In this basin are no less than fourteen seams, eight of which are over three feet in thickness. The depth of coal formation is already proved to 3,000 feet. In extent of area, number of seams, and quantity of coal, this is the most valuable of the several basins comprising the Sydney coal-field, it yields coal of the best kind for the manufacture of gas, domestic and steam purposes, and possesses the largest number of going collieries and the best railway facilities, which give access to the famous harbours of Sydney and Louisburgh, for two important railways intersect it, both running within easy distance of the several coal areas at present at work, and also of areas owned by speculators with license to work in the future.

On reference to the plan, Plate XXXVI., and section of strata (on line E F), Plate XXXV., the great size and importance of this basin, as well as the thickness and depth of its various coal seams and intervening

strata, will be readily understood. The names of seams already proved are as under in descending order :—

					Feet. In.	
No. 1 seam,	240 feet down,	Hub seam	...	...	9	6
2	770	Harbour seam	...	...	5	6
3	1,030	Boutilier seam	...	...	3	0
4	1,080	Back Pit seam	...	...	4	6
5	1,190	Phalen seam	...	...	8	0
6	1,330	Ross or Emery seam	...	...	4	6
7	1,420	Small seam	...	...	2	6
8	1,830	Lorway seam	...	...	4	0
9	2,290	Gardiner seam	...	...	4	9
10	2,400	Gardiner new seam	...	...	5	6
11	2,850	Clark's seam	...	...	2	0
12	3,100	Martin's seam	...	...	2	0
Total coal thickness					55	9

All the above seams have been proved and tried to some extent (down to No. 6 seam) from small workings in the cliffs from Glace Bay Head round to Lingan Sand Bar, which conclusively show their thickness and angle of dip. Below No. 6 the several seams have been fully proved by sinkings, borings and working slopes. The upper or Hub seam has been extensively worked by the Glace Bay Mining Company. At the Roost Slope and McLay Pit this seam is a very tender and friable coal, and is probably the easiest and cheapest worked seam in Cape Breton, nevertheless it has the reputation of yielding the best gas coal in the island, which also stands well for domestic purposes. The Harbour or International seam has been extensively worked by the Glace Bay Mining Company at their Harbour Pit, and by the International Mining Company at Bridgeport. At both places the coal has given great satisfaction, the seam working fine large blocks, much appreciated for gas and domestic purposes. The next working seam is the Phalen, which has been more extensively worked than any other in this section, at the Old Bridgeport Mines, owned by the General Mining Association of London, where a considerable amount was worked over thirty years ago; at present it is largely worked at the Reserve Mines, owned by the Cape Breton Coal Company of London. At Caledonia Colliery, owned by the Caledonia Mining Company, and at the Clyde or Ontario Mines, owned by Messrs. Campbell, of Halifax, the mineral from the Phalen seam turns out well, and gives general satisfaction as a gas and domestic coal. At the Old Bridgeport and Reserve Mines the Phalen seam is rather of an undulating character, but maintains an average dip of five

degrees. The next working seam in descending order is one partially worked at Schooner Pond, and there known as the Ross seam ; it is also worked at the Emery Mines, and known as the Emery seam. This coal is very friable, and easily worked, but does not make large coal ; it has a loose shale roof, and takes a good deal of timber, and from the appearance of the workings at Emery is well adapted for long-wall working. The coal, though small, gives great satisfaction, and is much looked after for domestic and other purposes.

Below the Ross or Emery seam comes the Lorway seam, four feet in thickness, of good clean coal. This seam has only been worked to a small extent at the Lorway West Pit, owned by the Cape Breton Company. Unlike any other seam in this section, the cleavage in the coal is very close and numerous at the face ; the section presents a firm, solid appearance, and with careful blasting makes good large coals ; but from its thin cleavage this coal is not adapted for banking during severe winters—in fact it is one of those seams that would prove most remunerative by being only worked during the summer months or the season of navigation.

Below the Lorway the next working seam is the Gardiner seam, which is the most westerly seam worked in this section. Within the last two years, this seam has been fully proved by the sinking of the Gardiner Pit, by the Gardiner Coal Mining Company of Montreal, and has been worked to some extent. This is probably the hardest seam of coal in this section, very much resembling in compactness and strength the low main seams on the Wear and the yard coal on the Tyne. This coal bears a good and increasing reputation as a steam coal, and is much sought after by Atlantic steam-ships.

About 130 feet below the Gardiner seam, another seam 5 feet 6 inches has been proved at the crop, which from the appearance of the coal would seem well adapted for gas purposes.

To westward of the above New Gardiner seam are two small seams named the Clark and Martin seams, of very fine coal, but not of sufficient thickness to work profitably in competition with the larger seams. So far as is known, these seams define the western limit of the Glace Bay Basin.

As will be seen from the map, basin No. 4 is separated from basin No. 3 by the anticlinal L M, running nearly east and west, and forming the range of hills between Cow Bay and Schooner Pond, over which the road from Schooner Pond to Cow Bay is made through a most formidable-looking lot of conglomerate boulders. This basin, from the fact of most of the seams being cut off by the waters of Cow Bay Harbour, is of limited ex-

tent, nevertheless it contains coal seams of a very valuable character. This may be said to be the only basin in the Sydney coal-field that has been thoroughly proved. In the Block House seam, slopes have been driven from the southern crop down through the lowest level of the basin and out again (at a greater angle) on the northern crop near the anticlinal, and again at the point, and the extent of the basin has been proved to the westward of Cow Bay. The thickness of coal measures proved in this basin is about 1,300 feet, containing seven seams of coal, five of them more than three feet thick, the highest and the most valuable, the Block House seam, being nine feet thick, but unfortunately in point of surface area this is the most limited in extent, and is almost entirely covered by the area of the Block House Mining Company. American geologists have endeavoured to identify this basin with that of Glace Bay, but the fact of the anticlinal intervening, the positive proof of the basin in the workings of the Block House seam, and the great disparity of the number of working seams in the two basins, practically discourage such a supposition. On the map, Plate XXXVI., is shown on the eastern side of Cow Bay Harbour a continuation of the seams running through the point of land between Cow Bay and Mira Bay. At False Bay Beach, the most southern point of Cow Bay, is found the Tracey seam. Up to this time this seam has not been found at any other place in the Sydney coal-field, and in all probability it curves round to the north in conformity to seams in the Block House basin, and is broken off by the anticlinal at or about the point. From its isolated position this seam has not been included in this paper among the seams in the Block House or Cow Bay basin.

As will be seen from the map and section of strata (on line G H) this basin contains the least surface area of coal and the smallest number of workable seams of any of the basins comprising the Sydney coal-field.

The first seam in descending order is the Block House, which has been worked very extensively by the Block House Mining Company of New York. This seam, like most seams yielding gas coals, is in some parts of a very friable character, but on the whole it yields coal of an average appearance, which for some years has been in great demand in New York and Boston as a gas coal. One strange and singular peculiarity in this seam is, that in many parts of the workings it is found for a distance of ten or twelve yards, thickly mixed with lumps of fire-clay like raisins in a plum pudding. In all cases where this disturbance occurs, the angle of dip remains the same. The workings in this seam have proved conclusively the basin formation of the district.

The only other seam working in this basin is the McAulay seam ; it

has been extensively worked by the Messrs. Archibald and Co., at the Gowrie Colliery, and has been found to be a good domestic coal, and has a good demand in the various provincial markets. This is about the only seam in Cape Breton that can be worked without blasting powder, owing to the existence at every four or five inches, of what is known in the north of England as "slippy backs." All the coal can be worked by wedging, or when good jnds are made it comes down of its own weight.

None of the other seams in this section have been proved by workings, but their existence, depth and angle of dip, have all been undoubtedly proved by trial pits near the several crops.

From the foregoing limited description of the Sydney coal-field it will be seen that the small island of Cape Breton is destined at some future day to take an important position in the coal-producing countries of the world. In order to show how capitalists are taking advantage of its mineral wealth, the writer purposes concluding this paper with a short account of the present working collieries, commencing with the pioneers of our Cape Breton coal trade

THE SYDNEY MINES

Which are located on the northern side of the Sydney or Spanish River, about one mile inland from Cranberry Head, the northern entrance of the river. This establishment is probably more like an English colliery than any other of the Cape Breton mines. Owned by the General Mining Association of London, a wealthy English Corporation, the whole of the equipments of this colliery are purely English. A stranger arriving at Sydney Bar from England after a long sea voyage, and seeing the old-fashioned chaldron or 53 cwt. coal wagons on the G. M. A. wharves, would fancy he was near one of the Newcastle collieries. The mining areas of the G.M.A. at the Sydney Mines consist of sixteen square miles of land area and seven square miles of submarine area. Several shafts have been sunk on this property to prove it satisfactorily. Their present working establishment consists of the Queen Pit coal shaft and Furnace Pit for working the land areas, and a pair of new shafts in course of sinking to work the Sydney Main seam, in the submarine area, the pumping shaft of which is down to the coal, a distance of 680 feet. The present plant at Queen Pit is equal to an output far exceeding any quantity that has been called for up to this time, and with the completion of the new winning, the Sydney Mines will be in a position to treble their heretofore highest sales. This colliery is connected with one of the best shipping places in Cape Breton by a short line of railway three miles long, (1) Plate XXXVI.,

leading from the colliery to the shipping place at North Bar on Sydney River, where extensive wharves are erected for shipment of coals to vessels of an average draught of 18 feet. New wharves are in course of erection to accommodate vessels of a larger draught ; the highest annual shipments from these mines have never much exceeded 110,000 tons. The mechanical plant in actual operation for raising and shipping coal is—one English hoisting engine, one English pumping engine, and two underground hauling engines, at Queen Pit; and a pair of English hoisting engines and one powerful English pumping engine, at the New Winning ; besides five English locomotives and a number of other smaller engines for various purposes. Crossing over Sydney River to the south is the

VICTORIA COLLIERY,

Or, as it is usually called, Victoria or Rosse's Mines, owned by Frazer and Co., of Halifax. This colliery is located on the southern bank of Sydney River, about two miles from Low Point lighthouse, and was established for working four square miles of coal underlying the waters at the mouth and entrance of Sydney River. With the exception of that portion of the underground works comprising a pair of slopes passing through the G.M.A. coal, all the works in this colliery are under water ; the seam is about six feet of clean coal, dipping at an angle of from 40 to 45 degrees. The colliery is connected by four miles of railway, (2) Plate XXXVI., leading to a shipping place owned by the company at South Bar or Sydney River (opposite North Bar), where wharves are erected in a sheltered position, with a good draught of water, for shipping coals. The working of this colliery is by a slope driven at the full dip of the seam, and coal is raised by a pair of 16 inch cylinder (colonial) engines. The water from the mines is forced by Cameron steam pumps up a separate pumping slope ; for working the railway, one of Neilson's (of Glasgow) tank locomotives is employed. The annual output, so far, has not been large, but it is capable of considerable extension. Five miles further south are the

LINGAN MINES,

Owned by the General Mining Association of London, and working the Lingan Main seam in No. 2 basin. For thickness of seam, quality of coal, and facilities for shipping, (3) Plate XXXVI., this colliery will compare favourably with any others in Cape Breton. A snug little harbour, with about 14 feet draught of water, lies about one mile from the slope, where coal can be shipped in all kinds of weather. The coal is raised from these

mines by a slope extending from the crop of the coal to the full dip of the seam, more than half-a-mile down under the sea. This colliery is well laid out, and capable of doing a large amount of work if required. Of late years the output has not been large, the highest number of tons sold previous to the abrogation of the Reciprocity Treaty, being about 52,000 tons. The coal from the Lingan Mines is purely a gas coal, and the produce is mainly dependent on the United States for a market; during the writer's management of these mines a good trade was done in Boston and New York. Wharves are laid out capable of shipping 800 tons per day, and if required, the channel into the harbour could be deepened to admit of larger vessels. The mechanical arrangements for working this mine consist of one old single cylinder English engine (the oldest in Cape Breton) for hauling coals and pumping water; and one of Black, Hawthorn, & Co.'s locomotives for hauling coals to the wharf; a pair of new engines are in course of erection for hauling out of the slope. During the last two years a portion of the underground works in this colliery has been damaged by fire from the flues of a boiler placed underground to work steam pumps, but it is satisfactory to know that the fire has now been put out, and that the works will soon be in their usual good order. The extent of coal area at Lingan Mines is about sixteen square miles land area, and eight square miles under the sea. Following the shore line and crossing over Lingan Bay, are the

INTERNATIONAL MINES,

Owned by the International Coal and Railway Company of New York. In extent of coal area these mines are the next largest to those of the General Mining Association of London, and contain five square miles of coal underlaid by nearly all the seams in the Glace Bay or No. 3 basin—of course many of them at great depths. The seam, at present worked by a shaft 80 feet in depth, is called the Harbour seam of Glace Bay, and is six feet in thickness. The coal from this seam at the International Mines is sold for gas purposes in the United States, where it has a good reputation. All of these works are comparatively new, having been erected during the past five years. The mines are connected by twelve miles of railway, (4) Plate XXXVI., to a splendid shipping place on the west side of the southern branch of the Sydney River, where an extensive pier, 1,000 feet long, has been erected for shipping coals to the largest class of vessels, having a draught of water varying from 16 up to 30 feet. The railway and wharves are all owned by the International Company in common with all the collieries that have a gas

coal dependent on the United States for a market. The output of these mines has fallen off on account of the present almost prohibitory duty on coal entering the United States; their highest sales have, however, been 82,000 tons. The mechanical arrangements for working these mines are one pair of 16 inch engines for hoisting coal, two Cameron steam pumps for raising water, three capital English locomotives and the usual number of coal cars. About three miles south-east from the International are the

GLACE BAY MINES,

Owned by the Glace Bay Mining Company of Halifax, and one of the first mining properties opened out after the abandonment of the mining rights in Nova Scotia by the General Mining Association of London. As one of the first parties taking up areas at this time, this company would seem to have been short-sighted in taking such a small area. Their mining rights extend over an area of two-and-a-half square miles, underlaid by the whole of the seams in the Glace Bay basin, the greatest number of them lying at great depths. This property has been fully developed in the two upper seams, viz., the Hub and Harbour seams, to both of which, pits have been sunk and extensively worked. The produce of both seams has an excellent reputation as a gas coal, and is largely consumed in the Boston and New York markets. The Hub seam is one of the highest seams in the Sydney coal-field, and probably the easiest coal to work. As will be seen from the map, the Glace Bay Company own the whole of the coal in this seam, which is only of a limited extent, and their present pit and openings are sufficient to work all the coal. The produce from this seam is brought to the shipping place by a short line of railway one mile long, (5) Plate XXXVI. The Harbour seam is worked by a shaft 40 feet deep, so near the wharves that the coal is shipped direct from the tubs coming out of the pit, the heapstead forming the wharf, and the coals being riddled in the pit. This company has great facilities for shipping coal, owning the entire rights and privileges of Little Glace Bay Harbour, and having sufficient depth of water to load vessels down to 18 feet draught. Like Lingan and Cow Bay, this harbour is useful for shipping coals later in the season than is practicable at wharves situated on the upper part of Sydney River, but owing to their being on the sea-board, they are all somewhat more exposed. The mechanical arrangements of these mines are all of American manufacture, and much lighter than our English mining machinery. The railway is worked by a small tank locomotive, made by Neilson, of Glasgow. Two new pits are at present being sunk to a depth of 250 feet down to the

Harbour seam, which, when finished, will considerably increase the facilities for raising coal. The largest output from these mines has been somewhat over 70,000 tons. Owing to their coal being principally disposed of in the United States, their sales are considerably reduced by the duty recently imposed on all coals going there.

CALEDONIA COLLIERY

Is also located in Glace Bay, about one mile from Little Glace Bay Harbour. This colliery is owned by the Caledonian Coal and Railway Company of Boston, who own two square miles of mining area, underlaid by all the seams in Glace Bay basin, under the Harbour seam. This colliery is, comparatively speaking, new, having only commenced to ship coal about six years ago. Two pits are sunk to the Phalen seam, which is the only coal mined by this company. Like all the mines producing a gas coal, this colliery is dependent on the United States for a market, and is seriously affected in its sales by the duty imposed on coal going there. The mechanical arrangements are of a first-class character, the hoisting engine being of American make, and very powerful. The colliery is connected by a railway two-and-a-half miles in length, (6) Plate XXXVI., to the shipping place, which is a dock made by the company at the southern end of Big Glace Bay sand bar, at a very great expense, and called Port Caledonia. The mouth of the harbour is much affected by north-east gales, which have a tendency to cause the entrance to fill up with sand; otherwise, it is perfectly safe. As at Lingan and Glace Bay, this company keep a powerful tug-boat to tow vessels in and out of harbour. The railway is worked by a powerful locomotive, built by Neilson, of Glasgow. On the south side of Caledonia Harbour, about one mile along the shore, are the

CLYDE MINES,

Or, as they are sometimes called, the Ontario Colliery, owned by the Messrs. Campbell, of Halifax. This is a splendid property of one-and-a-half square miles, but, so far, very little work has been done. The seam has been opened out by a slope to its full dip. The coal worked here is the same as at the Caledonia, being the Phalen seam of 8 feet 6 inches in thickness. On account of the small quantity worked, the produce of this mine has not extended much beyond the Halifax market, where it has the reputation of being a good domestic coal. No plant of any consequence has been erected here, there being only a small American hauling engine for drawing coals up the slope. The tubs are hauled a distance of about a

mile to Caledonia Harbour, (7) Plate XXXVI., and shipped to vessels direct; coal worked during the shipping season being riddled and cleaned in the pit (as at Glace Bay Harbour Pit and also at the Block House Mines). In proportion to the extent of the mining area, this is probably as fine a property as any in the Sydney coal-field, and but for the serious drawback on our coal trade, caused by the abrogation of the Reciprocity Treaty in 1867, would ere this have been extensively worked. About two miles further south along the shore is

SCHOONER POND COLLIERY,

Owned by the Cape Breton Coal and Railway Company of London, having a mining area of two square miles, the principal portion of which is a sub-marine area extending from the shore (outside of the Clyde area), some distance under the waters of the Atlantic. Very little has been done here beyond driving a pair of slopes through the coal in the Clyde area to reach the coal under the sea owned by the Schooner Pond Company. No plant of an extensive character has as yet been put up here except the heapstead, a small engine, and some screens. Owing to the depression of the trade last year, the company deemed it advisable to suspend operations and supply demands from their other collieries. The Ross seam, or, as it is now called, the Emery seam, is worked at these mines. The coal is much thicker than at the Emery in some places, but of about the same quality. A splendid narrow (three feet gauge) railway, of 18 miles in length, (8) Plate XXXVI., connects this mine with the shipping port in Sydney River, and its limited produce has been shipped there. A portion of Schooner Pond area lies to the north-east (under the sea), and another portion lies to the south-west (under the land) of the Clyde area, and it would seem one of those cases where an amalgamation of two properties would be immensely beneficial to the owners of both, especially as they could be both worked with one plant. Crossing over the Anticlinal L. M., are the

BLOCK HOUSE MINES.

Forming one of the most extensive of the new collieries, opened out during the past twelve or fourteen years. These mines are owned by the Block House Mining Company of New York, and have a mining area of two square miles. The seam worked here is the upper seam in No. 4, or Block House basin, and called the Block House seam, which is not in any other area. The coal from this seam is mostly sent to New York and Boston, where it has the reputation of being a first-class gas coal.

From circumstances before named, the sales of this colliery have fallen off considerably during the last few years, although an extensive plant is erected for doing a large work. The seam is about nine feet in thickness, and in this area are all the seams in the Block House basin. The coal from Block House is worked by both a pit and a pair of slopes. In winter time, when the coal is banked, it is all worked by the pit. During the shipping season all the coal is worked by the slopes coming out at the crop of the coal in the cliffs, tubs going direct on to the wharf are teemed direct into the vessels, the coal having been previously riddled and cleaned in the pit. This colliery enjoys many facilities over others in having no surface hauling, and vessels being able to moor close alongside the mouth of the slope, (9) Plate XXXVI. The progress of these works is greatly retarded by the present uncertain character of the shipping place. When the wind is blowing from certain quarters no coals can be shipped, owing to a heavy swell coming in from sea, and gales often cause serious damage to the wharf and shipping property. This is one of the mining properties that would be greatly benefited by a connection with the Glasgow and Cape Breton Railway leading into Sydney, for the regularity of work ensured by shipping in a safe harbour would more than compensate for railway dues on the coal carried. About a mile to westward of Block House are the

GOWRIE MINES,

Owned by the Messrs. Archibald and Company, of North Sydney. This mine works what is termed the McAulay seam, which is the second seam in the Block House area, and is 4 feet 10 inches in thickness. The extent of mining area held by this company is two square miles, underlaid by all the seams under the McAulay. The coal from this seam works small, and makes a considerable amount of slack, but owing to no blasting powder being used, the coal stands the severe Cape Breton winters. Unlike any other of the new collieries, this one, up to the end of 1873, has year by year largely increased its sales. This is in a great measure owing to the Messrs. Archibald giving their attention almost entirely to placing their coal in the neighbouring provincial markets and in the West Indies, which makes them to a great extent free from the changes and fluctuations of the United States markets. From trials in the American Gasworks, this coal has a fair reputation for making gas, but it is principally used as a domestic and steam coal. The McAulay seam at this colliery is worked by a shaft of 200 feet deep, but a pair of shafts are in course of sinking to win the coal further

to the dip. The mechanical arrangements for hoisting coal and pumping water are of an old-fashioned character, one engine (on the second motion) doing both the hoisting and pumping. The pit is connected to the shipping place by about a mile of railway, (10) Plate XXXVI., steeply descending and worked nearly the whole distance by a self-acting incline. The shipping place here is much safer than at Block House, being inside a strong breakwater first erected by the enterprising proprietor for the protection of the coal wharf, but since purchased by the Dominion Government as a general shelter for shipping seeking business in Cow Bay. Even with this protection heavy gales cause great destruction in some seasons. Taking a stretch across the country inland, and again crossing the Anticlinal L. M. in a northern direction, to a distance of about eight miles, the collieries of the Cape Breton Coal Company of London are reached, the first of which is the

RESERVE COLLIERY,

So called from the fact of this area being set apart by the Provincial Government as a mining reservation to encourage the building of a railway from Sydney for the conveyance of coals. The mining area is one square mile, and contains all the seams in the Glace Bay basin, below Back Pit, or No. 4 seam. This colliery is working coal from the Phalen seam by a pair of diverging slopes, hauling coals out of each, and is well laid out underground for doing a large amount of work, the plant and mechanical arrangements being of the best and most substantial character. The coal from this seam has been sent to various markets, and will no doubt on trial be found suitable for gas and domestic purposes. From analysis it yields a fair proportion of gas, and has given great satisfaction as a steam coal. The coal from the mine turns out large and looks well, and makes about the usual amount (10 per cent.) of slack on fresh mined coals. About one mile to westward is the

EMERY COLLIERY,

Also owned by the Cape Breton Company. This colliery is worked by a slope in the Ross seam of Schooner Pond, or the Emery seam, as it is called here. These works are comparatively new, 1874 being the year they commenced shipments. The Ross seam is here about five feet thick, and of a much more tender character than further south; it has a loose roof, indicating its suitability for long-wall working. Coals from this seam are not worked large, owing to its thin cleavage. From the short time the works have been in operation the character of this coal is not yet generally known,

but from appearance there is no doubt of its being useful for gas and domestic purposes. The extent of mining area is two square miles. The mechanical arrangements are of the same style and character as those at the Reserve Colliery, and the mines at both places are kept free from water by Cameron's steam pumps. Adjoining this area is the Lorway Mining area of two square miles, owned by the Cape Breton Company. One pit has been sunk down to a depth of about 70 feet, but beyond being holed round, nothing has been done in working; a pair of pits have also been in course of sinking for three years, but as yet are only down about 130 feet, and no sinking has been done at them for more than twelve months. All the mines in operation owned by the Cape Breton Company are connected to their shipping place on Sydney River by a private railway of three feet gauge, about twelve miles long, (11) Plate XXXVI. The railway is worked by three English locomotives (two of them are Fairley's twin engines), and the usual number of coal cars for doing good work. A branch railway is being built to connect the several collieries with the old French harbour of Louisburgh. The length of this branch will be about 22 miles, and it is hoped on its completion it will give an outlet for coals during winter when the rest of the coal ports are closed. The shipping wharf owned by this company is of a most substantial character, and capable of accommodating vessels of great draught, and shipping the coals with every facility; being about two miles further up the southern branch of Sydney River than the International wharf, it is liable to be sooner frozen up, but this makes no difference with regard to the opening of the navigation, as the ice generally moves from all places at once. Two miles further to the north of Lorway, on the shores of the Lingan basin, is

GARDINER COLLIERY,

Owned by the Gardiner Coal Mining Company, of Montreal. The mining area is two square miles in extent, and is underlaid by the present working Gardiner seam and another good seam five feet six inches in thickness, besides the smaller seams known as Clark and Martin's seams in Glace Bay, or No. 3 basin. This colliery is admirably situated, (14) Plate XXXVI., being close alongside of the International Railway, and only eight miles from Sydney River, where the produce is shipped from the International Company's pier. This colliery is the only one having a pit sunk at the extreme dip of the area, and having all the coal to work to the rise. The works are comparatively new, for sinking only commenced in July, 1872. The pit

is about 160 feet deep. The mechanical arrangements are of the most substantial character, the hoisting engine being made by the Messrs. Coupe, of Wigan; the pit is drained by two of Cameron's steam pumps, made in New York, which give great satisfaction. This pit, although not deep, made an immense deal of water during sinking, and was the first pit sunk in Cape Breton with steam pumps. The seam at present worked is about four feet nine inches in thickness, of a good strong coal, said by miners to be the hardest in Cape Breton, and is, so far as experience has proved, the only real steam coal there. Having only been a short time in operation, the coal has been in great demand for steam purposes, and has found a ready sale to the Allan and other steam ship companies. The works underground are well laid out, and in case of increased demand, could raise a large quantity of coals. This is the only colliery in Cape Breton that has as yet taken advantage of other railways for the purpose of shipping coal. An agreement is made with the International Company to carry and ship Gardiner coal, finding cars, &c., at a fixed rate per ton on a sliding scale of five cents. (about twopence halfpenny) less on each 25,000 tons shipped.

UNWORKED MINING AREAS.

Besides the mining areas worked by the before-mentioned collieries, a number of excellent mining rights are held by various parties under lease from the Provincial Government, in close proximity to the Cape Breton and international railways, and in case of a good demand for coal in this island, could be soon opened out to advantage. Among those on the line of railway, leading to Schooner Pond, are three areas of one square mile each, owned by Messrs. Brookman and Moseley, of Sydney, and another owned by a Mr. Protheroe, these four areas will be underlaid by the Gardiner seams, and the two small seams, called Clark and Martin's. The Schooner Pond branch of the Cape Breton Railway could be made available for these areas by a very short branch to each. On the line of the International Railway are three first-class mining areas, first is the G.M.A. Bridge Pont area of two square miles, a splendid property, underlaid by all the seams in Glace Bay basin, below Back Pit or No. 4 seam, the Phalen seam being fully proved by some acres of workings; to the west again is the mining area owned by Mr. Kirby, of Halifax, and one square mile in extent, underlaid by seams under the Phalen in the Glace Bay basin. Between this and the Gardiner area is about one square mile, owned by Dr. Jennings, of Halifax, underlaid partly by the Lorway and Gardiner seams, all these three areas could be won by sidings in

connection with the International Railway. Between Glace Bay mining area, and those held by the International Company, is a triangular mining area, owned by a Mr. Campbell, of Ottawa, it is about one square mile in extent, but cut off from direct railway and harbour facilities. This is capital property, and would be a good acquisition to the Glace Bay, or the already large mining area of the International Company. In either case it could be won from their present pits without any outlay of consequence.

From the before-mentioned slight description of the collieries, it will be seen what efforts have been made to utilize these vast stores of coal. Perhaps it may be said not much has been done in order to take advantage of such a large provision of this almost indispensable mineral ; but it must be borne in mind, that previous to 1858, all the minerals (with but few exceptions) were owned by a wealthy London Corporation, who in that year abandoned nearly all their claims, retaining only those in which they had collieries established, and thus throwing an immense area of mining property into the hands of the Dominion Government, who, in order to properly regulate and manage the same, had to wait until the requisite legislation could be passed through. Up to the year 1862, the time was spent in prospecting, making harbours, and forming various companies for working the new mining properties, after which year the new companies may be said to have got fairly into harness. The following table will show the progress made up to the end of 1874 :—

TABULAR STATEMENT OF COALS RAISED ANNUALLY AT THE SEVERAL COLLIERIES IN THE SYDNEY COAL-FIELD, CAPE
BRETON COUNTY, UP TO YEAR ENDING 1874.

Mark of Pit or Slope on Plan.	NAME OF COLLIERY.	1858.		1859.		1860.		1861.		1862.		1863.		1864.		1865.		1866.		1867.		1868.		1869.		1870.		1871.		1872.		1873.		1874.		
		Tons.		Tons.		Tons.		Tons.		Tons.		Tons.		Tons.		Tons.		Tons.		Tons.		Tons.		Tons.		Tons.		Tons.		Tons.		Tons.		Tons.		
0	G. M. A. Mines previous to 1858 ..	1,819,899																																		
1	Sydney Mines ..		100,872	100,730	117,616	100,458	111,681	104,373	88,580	108,579	109,168	101,918	97,470	95,733	108,951	105,494	102,690	127,393	96,958																	
2	Victoria Mines ..												287	2,526	4,905	7,288	17,452	19,422	12,809	15,310																
3	Lingan Mines ..		40,042	9,299	16,298	35,300	34,203	36,059	44,372	55,108	50,686	37,150	20,736	30,377	25,744	21,940	38,504	36,720	19,697																	
4	International Mines ..		696	1,358	1,937	1,480	2,548	4,198	6,719	16,374	10,720	20,807	5,769	7,510	10,640	80,261	20,498	75,380	36,385																	
5	Glace Bay Mines ..		469	2,373	2,297	5,544	7,720	26,724	72,077	82,247	57,905	52,026	49,719	29,615	55,783	39,515	30,715	63,199	46,535																	
6	Caledonia Mines ..																																			
7	Clyde or Ontario Mines ..								30	508	8,762	5,955	253	851	2,279	2,125	1,830	2,600	8,394	7,070																
8	Schooner Pond Mines ..								370	1,360	6,337	973	37		53			1,268	13,901	1,523																
9	Block House Mines ..				3,736	7,622	16,934	15,690	70,650	91,600	89,914	71,226	36,965	73,933	40,006	3,768	42,748	52,571	28,897																	
10	Gowrie Mines ..								2,876	15,070	28,738	43,770	33,324	38,618	47,003	40,609	52,877	42,431	59,625	32,857																
11	Reserve Mines ..																																			
12	Lorway Mines ..																																			
13	Emery Mines ..																																			
14	Gardiner Mines ..																																			
	Sundry Mines ..			450	1,520	3,818	8,191	6,907	5,966	6,791	1,633	1,220	2,417	437	40																					
TOTALS ..		1,819,899	142,079	123,210	143,404	154,222	184,563	207,889	328,108	414,204	359,352	323,437	273,283	317,292	331,340	338,346	378,615	631,832	345,739																	

NOTE.—Above Table is compiled from Brown's Statistics and Government Returns.

From the foregoing tabular statement it will be seen that the Cape Breton coal trade began to expand after the abandonment of the monopoly by the General Mining Association. From 1861, to and including 1865, the production of coals was considerably increased by the demand for provincial coals in the United States markets, consequent on the war between the Northern and Southern States, during which time very little coal was carried in American, or, more properly speaking, United States vessels, owing to the fear of capture by Southern cruisers. Provincial shipowners, as well as coal-owners, reaped a good harvest during the continuance of the war. This good fortune was not destined to last long. The enormous demands on the United States treasury during the war compelled that Government to put a duty of 1·25 dols. or 5s. sterling per ton on provincial and other coals in 1866, and consequently a decrease of shipments is shown from 1865 up to and including 1868. Circumstances having arisen to warrant the United States Government in making a reduction of 50 cents, or 2s. sterling per ton in the duty in 1868, the shipments again began to show an improvement; and in 1873 they more than doubled those of 1869; but this increase was assisted by the high price of coal in England, which enabled steamers to buy bunker coal at a much cheaper rate in Cape Breton. There was also greater demand for Cape Breton coal up the Saint Lawrence, from the fact of sailing vessels not bringing so much coal out for ballast as was done in former years. As will be seen from the table, this was only a temporary increase, for in 1874 the produce of coals was reduced over 230,000 tons, the falling off in the shipments to the United States being 135,599 tons, caused, to a certain extent, by the overstocked markets of 1873 and to the sudden financial panic in the fall of that year, which unsettled the commercial machinery on the whole of the Atlantic seaboard of the United States. Much as Cape Breton coal-owners may deplore the loss of trade in the United States in 1874, it is very gratifying to find the demand for coal so much increased in the neighbouring provinces as to bring the production nearly up to that of 1865, the year in which over half the production of the Cape Breton mines was shipped to the United States. This shows that in the last nine years there has been a steady annual increased demand in the provinces for Cape Breton coal approximating to 85 per cent. Should ever the time arrive for the Dominion Government to follow the example of America and place a tax on all coal coming into the dominion of Canada, there will then be almost a sufficient demand for the whole of the coal produced in the Nova Scotia collieries. Generally at present the coal interest has to contend with coal coming to

Canada from the United States duty free ; coal from England, brought out as ballast by the large vessels coming for grain and timber, and generally sold *ex ship* at a price to cover first cost, without allowing anything for freight—this is a sad arrangement for the colonial coal-owners, as the quantity imported is so great as in a measure to fix selling prices ;—and lastly, the almost prohibitory duty on coal going to the United States. The following tabular statement is intended to show the economic value of the several seams in the Sydney coal-field :—

COMPARATIVE TABULAR STATEMENT OF THE ANALYSIS AND ECONOMIC VALUE OF THE COAL SEAMS IN THE
SYDNEY COAL-FIELD, CAPE BRETON COUNTY, NOVA SCOTIA, B.N.A.

Name of Seam.	Name of Mine where Worked.	Thick- ness of Seam.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Cub. ft. of Gas per Ton.	Calorific value in lbs of wair per lb. of coal.	Authority for Analysis.	Course and Angle of Dip.
Sydney Main	Sydney Mines	6 0	32.74	61.54	5.72	3.37	8,206	8.49	How and Baist	No. 60 E., Angle 6°.
Davy's Head	Victoria Mines	6 6	38.70	58.40	2.90	..	8,000	8.02	Dawson	No. 3 W., " 40°.
Lingan Main	Lingan Mines	8 6	30.03	66.90	3.07	.77	9,600	9.97	How and Baist	No. 37 E., " 12°.
Harbour Seam	International Mines	5 6	34.00	62.92	2.99	2.25	10,000	7.76	New York Gas Co.	No. 84 E., " 5°.
"	Glouce Bay Mines	5 0	30.21	67.78	2.01	0.90	10,000	9.31	Harrington	No. 27 E., " 5°.
Hub Seam	"	9 6	28.62	68.14	3.24	2.29	10,000	8.59	"	No. 50 E., " 5°.
Phalen Seam	Caledonia Mines	8 0	33.00	57.37	9.63	..	9,700	7.88	H. Poole, Esq.	No. 27 E., " 5°.
"	Reserve Mines	6 0	37.26	58.39	4.35	2.06	9,500	8.02	Harrington, &c.	No. 58 E., " 5°.
"	Clyde Mines	8 0	32.82	64.33	2.85	2.17	9,700	7.88	"	No. 21 E., " 5°.
Ross or Emery	Schooner Pond Mines	7 0	38.10	58.46	3.44	1.21	9,500	8.03	"	No. 23 E., " 8°.
"	Emery Mines	5 0	38.10	58.46	3.44	1.21	9,500	8.03	"	"
Gardiner	Gardiner Mines	4 9	34.33	61.97	3.70	..	10,700	8.51	Dawson and others	No. 85 E., " 5°.
Lorway Seam	Lorway W. Pit	4 0	34.84	55.98	13.28	6.27	9,500	8.02	Harrington and others	No. 51 E., " 5°.
Block House	Block House Mines	9 0	31.94	62.79	5.27	3.76	10,500	7.67	"	No. 21 E., " 6°.
McAulay	Gowrie Mines	4 10	36.25	53.05	5.70	2.34	9,000	7.97	Richard and Baist	No. 18 E., " 7°.
	Average	..	34.07	61.43	4.77	2.39	9,560	8.21		

In the foregoing tabular statements it will be understood that the results are obtained from laboratory analysis, except those as to the production of gas, which are given from the reports of the various companies who have tried the coals for gas purposes. The specific gravity is not given from the fact of it not being generally looked for in analyses got up for mining companies. From the writer's own experiments the mean specific gravity of Cape Breton coal is about 1·327 in comparison with other bituminous coals. On this continent and in England the bituminous coals of this coal-field compare very favourably with coals from the undermentioned places :—

			Vol. Matter.	Carbon.	Ash.
Pennsylvania, United States	...	...	29·50	64·40	6·10
Virginia	„	...	33·68	57·76	8·56
Indiana	„	...	39·00	52·00	9·00
Illinois	„	...	36·59	59·47	3·94
Iowa	„	...	41·00	48·50	7·50
Missouri	„	...	34·06	50·81	15·13
Newcastle, England	...	...	37·60	57·00	5·40
Staffordshire,	„	...	37·86	59·64	2·50
Derbyshire,	„	...	35·10	61·65	3·25
Yorkshire,	„	...	35·67	62·08	2·25
North Wales	„	...	36·56	57·49	6·25
Pictou, Nova Scotia	...	...	29·63	56·98	13·39
Sydney, Cape Breton	...	...	34·07	61·43	2·39

For gas purposes the Cape Breton coals have given general satisfaction in the United States for a number of years, and, but for the very excessive duty, would be taken in preference to their own bituminous coals; even with the duty, were it not for the severe and long winters in this country, Cape Breton coals would be in much greater demand in New York. The season for shipping usually ends in the latter part of December, after which the harbours are closed by ice until the beginning of May, so that consumers using this coal are under the necessity of laying in large stocks to serve over winter, and producers have to bank coal during the winter months at the mines in order to keep the men employed and to be ready for quick shipments; in both cases considerable loss from depreciation and from the expense of lifting coals from the banks is incurred.

Before closing these notes, it may not be out of place to make a few remarks on the system of working, and the prices for cutting or hewing coal, &c., in this coal-field. As will be seen from the map, and from previous observations, all the seams of coal crop out at the surface; although not showing any visible indications, yet the fact of the

existence of full sections of coal seams in the cliffs enables prospectors to soon fix on the locality of the crop, and commence operations by driving down a slope on the full dip of the seam. Much injury has been done to the character of many of our Cape Breton coals, by the almost popular practice of opening out the mines by means of slopes, for speculators in coal areas no sooner got slopes down, say 100 feet, than they rushed their coal into the market, companies were formed, and the mineral within 100 yards from the crop, which is of the poorest quality, was placed in competition with better coals from the same district, which practice, in many cases, was attended with bad results that took years to overcome. To give some idea of the popularity of the practice of opening out the mines in this coal-field by slopes, it may be stated that the only collieries opened out by properly sinking shafts are only the old Sydney mines, sunk over thirty years ago, the Caledonia mines sunk in 1868, and the Gardiner in 1872. Many of the companies now raise their coal from shafts, but pump the water up the slopes. The system of working the coal is principally the bord and pillar system, or, as it is called here, the room and rib style. From the writer's observations, he would be disposed to call the system of working previous to 1866 or 1867 (and partially so now) the bord and stook system, for certainly no practical man ever saw such small pillars as were left in working the coal; five yards square was considered a good sized pillar to leave, and some have come under the writer's notice only twelve feet by ten feet. Of course, in such cases, the managers never intended to touch the pillars, not having the fear of a check viewer before their eyes who might seek to check such waste of coal. In consequence of this, hundreds of acres of coal are standing in small pillars, which in many cases, it would be hazardous and expensive to take out, as they are already partially crushed. Not a pillar of coal was taken out previous to 1865, when the writer of these notes, on taking the management of the Lingan mines, commenced taking out the pillars in the upper lift next the crop, and for some time was very successful, until the pillars became small and crushed. It was then given up in that lift, and a larger scale of pillars adopted, which enabled them to work broken coal continually at the Lingan mines. The same plan has been adopted at many other places. In 1866, Mr. Rutherford, on his appointment as Inspector of Mines, or, properly speaking, check-viewer for the whole province, called the attention of managers and owners to the importance of leaving larger pillars and working broken, and to this and other suggestions from him may fairly be attributed much of the improvement in the underground workings at the several mines in

the Sydney coal-field. The primitive mode of working by generally taking advantage of the coal nearest the crop, and improperly leaving small pillars (in most cases never intended to be taken out), together with the formation of large wastes, was no doubt, in a great measure, the result of one wealthy corporation being, previous to 1858, owners of all the coal in the province, enjoying an absolute monopoly, completely debarring any competition on the island, and having an unusually large royalty to work, with no check viewer to consult as to the modes of working, scale of pillarage, or waste of coal. Sydney and Lingan mines being the only ones in operation in 1858, when the General Mining Association abandoned the monopoly of coal in the province; when new mines began to open out, proprietors generally availed themselves of the services of the most intelligent colliers from Sydney and Lingan as overmen, who usually adopted the mode of underground working there, as a model, irrespective of thickness of seam, quality of coal, nature of roof or thill, or thickness of overlying strata, and hence caused the perpetuation of the small useless pillars and immense waste of good coal, and the formation of extensive and unventilated wastes in the mines generally, until the introduction of men having practical training as colliery managers and mining engineers caused a change.

The system of paying for coal hewing, or coal cutting as it is called, varies at nearly every colliery. Some pay by the ton on all coal not passing through a half-inch riddle (slack left in pit), others pay by cubic yard, some by running yard, and again, others pay by the tub; but in all cases the holings and shearings (kirving and nicking) are passed over a half-inch riddle, and the slack is left in the pit. The amount of slack taken out from screening over a half-inch screen is, on an average, about 20 per cent. Taking a six feet seam as a basis, the cost per ton for coal hewing (with coal riddled in pit as above), is about 50 cents. or 2s. sterling per ton.

In conclusion, it is hoped these few notes will give the members of our Institution some idea of the valuable coal-field in the island of Cape Breton.

The Secretary was desired to convey the thanks of the members of the Institute to Mr. Gilpin and Mr. Routledge for their valuable contributions.

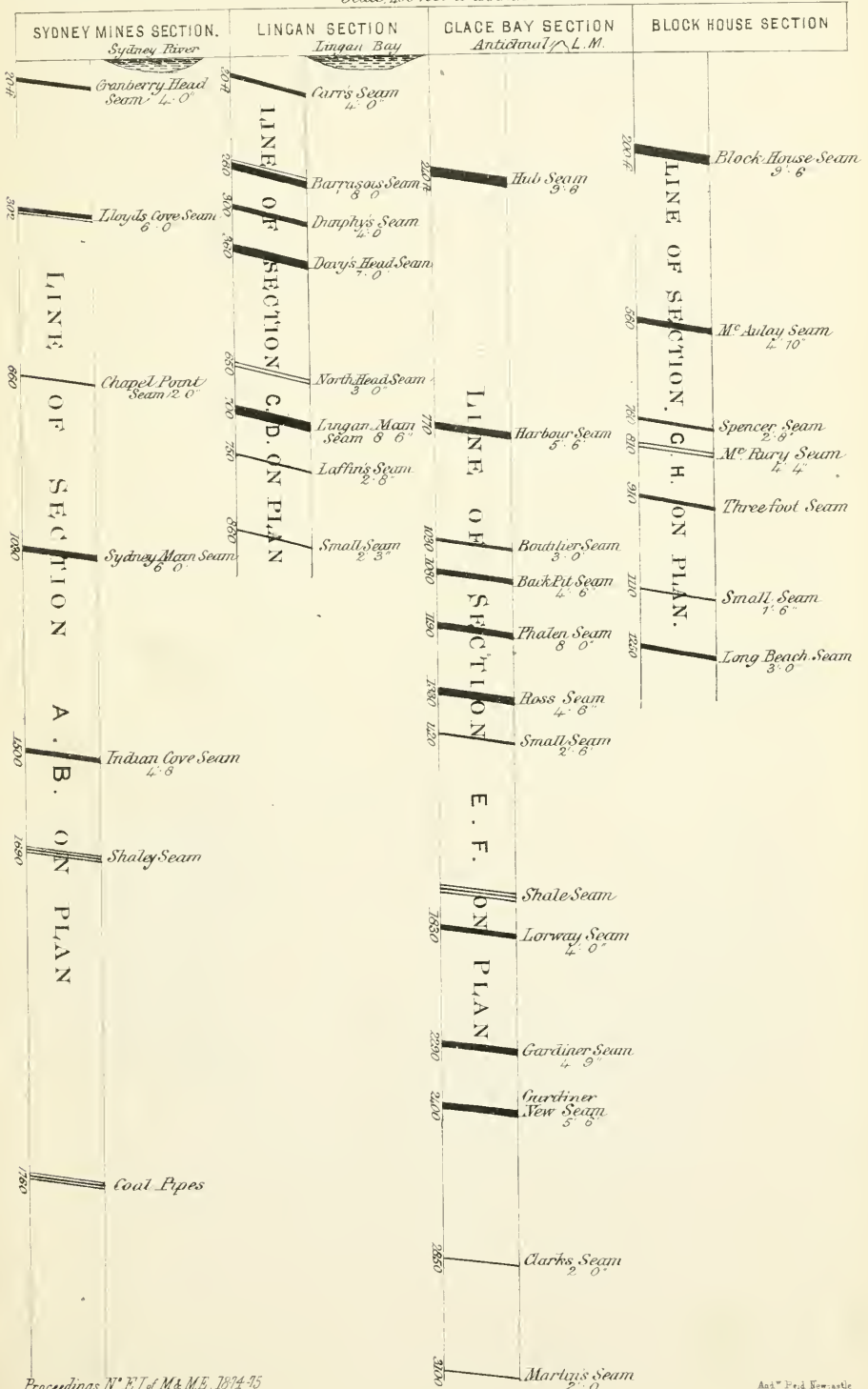
Mr. J. A. RAMSAY then read the following paper on "Projected International Railway Communication," communicated by Mr. W. T. Mulvany:—

To illustrate Mr. W^m Routledge's paper on the Sydney Coal Field

SECTIONS OF STRATA

Shewing Coal Seams in the several Coal Basins comprising the Sydney Coal Field, Cape Breton County in the Island of Cape Breton, Province of Nova Scotia, British North America

Scale, 400 Feet to an inch



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PROJECTED INTERNATIONAL COMMUNICATION IN THE
NORTH AND EAST OF EUROPE, THROUGH THE NEW
HARBOUR OF FLUSHING, AT THE MOUTH OF THE
SCHELDT, IN HOLLAND.

COMMUNICATED BY WM. T. MULVANY.

INTRODUCTORY REMARKS.

THE ceremonial of opening the New Harbour and Docks at Flushing, to which the writer was invited, induced him to put hastily together for the occasion the views and opinions which he had long entertained on the subject of international communication.

The writer would not have presumed to propose such large measures as are herein contemplated had he not felt that, having no local interest in the question, and at his time of life no personal objects to serve, impartiality on the part of the proposer might render the project worthy of some consideration by all those who, though deeply concerned, may have different and conflicting interests involved, and who may, through the suggestions herein offered, at least find a basis or starting point for the useful discussion and determination of the measures to be adopted.

To the projectors and engineers of railways who may find fault with his criticism, he can only plead that his object is simply to help in perfecting the plans upon which their future progress depends; and above all to show that in the interests of the railways themselves each portion should constitute as far as possible a suitable part of the great whole, which will remain to be criticised by our successors and by history.

Finally, he wishes to add his humble mite to that great progressive movement which is daily breaking down the barriers of separation between nations, and which, by facilitating frequent and easy intercommunication, will by degrees tend to such a reciprocity of interests as may be best calculated to ensure friendly relations and peace.

RAILWAYS.

In order to obtain the maximum of advantages and the utmost speed consistent with safety in the personal and postal communications between

nations, well laid out railways by land, and deep harbours accessible at all times for the most powerful steamers by water, both in the nearest practical direct route, constitute plainly the first essentials of success.

The great mission of railways cannot, however, be fulfilled until they are made perfect in design, construction, and use.

Even now it can be plainly seen how completely all old world maxims, all theories and experiences in great political war and commercial questions, are altered or nullified by the progress and extension of railways and improved modes of communication, especially when these are not confined to any one country, but extend over the boundaries of several countries, constituting, by degrees, a net-work over vast continents, combined with steam navigation all over the world.

Mankind is surprised at the results of recent wars,—at the sudden great influx and reflux of money, and the other rapidly occurring crises in money matters,—at the sudden flood of prosperity following the establishment of peace, and last, not least, at the rapid spread of enlarged and sounder views on religion and education ; but the moving and immediate mechanical causes of these results—steam and electricity, railways, steam-ships, and the telegraph—with their daily accumulative results on the whole life and business of man, must be palpably plain to all calm reflecting minds.

Those nations which have not yet obtained the advantage of these mechanical means of progress cannot longer hold their place without them ; unknown countries, deserts and wilds must be slowly but surely opened up and rendered available for mankind and civilization by the importation of these invincible conquerors, these, in reality, most suitable though slow means of secure discovery and development, and it cannot be doubted that ere long the very heart of Africa, which has so long been hidden from civilized man, will by these means be traversed and made accessible to civilization.

But if it be a want or a duty to extend these benefits to countries which have not hitherto enjoyed them, how much more is it essential for the Governments of old countries to make their systems of communication perfect and adequate, not merely to their present wants, (as was the economic rule in old times, “to let the necessity or want beget the improvement”) but also for those rapidly and surely coming increased wants which it is the peculiar feature of these improved systems themselves to beget.

The traffic consequent upon, or actually created by, railways, far exceeds that which ever existed or could be calculated upon before their

construction, and within reasonable limits this may fairly be expected to be the consequence of new lines.

The old railway nations of Europe, if they will maintain their status and the superiority which they have hitherto obtained by their works, must go on, must improve and complete their systems of communication; and each is especially bound in its own interest to do so in connection with the progress of its neighbour.

In this great question of communication, little or no attention appears to have been given to any general or international plan. Each country has adopted its own plan, or, perhaps, more properly said, no plan, for if one examines the railway maps of Europe there is, even in each separate country, little evidence as yet of a carefully, previously devised, general plan, of which each line, as constructed, was to form a part; with perhaps the exception of France, where centralization and radiation from Paris as a centre (on the principle that Paris was France) forms a clear and prominent feature of a previously-devised plan.

In England, as is well known, no general plan, not even a general railway law was originally made, railways were initiated by joint-stock companies as each thought most advantageous, and rectification of plan took place subsequently under the pressure of a stimulating competition between a great number of companies.

In Belgium there is no other evidence of a plan up to any recent date, except a general net, as it were, by which towns are connected with each other.

In Holland there is much more evidence of a plan, no doubt because with two exceptions the railways were only recently undertaken, and because so large a portion was constructed by the Government.

From Germany, taken as a whole, with its numerous states and their separate systems, and even from Prussia, separated as it was up to a late period in different parts by intervening small independent states, it was not expected that much uniformity or singleness of plan could be carried out, and this is sufficiently evident in the result.

Still in Prussia, notwithstanding its mixed system of State railways, private railways managed by private companies and private railways managed by the State, there is still evidence of the perpetual struggle, as it were, which the Government has, under such disadvantages, been making to carry out a plan upon given principles, of which the late main object seems to be to maintain the mixed system, and to counteract the effect of some of the evils which arise perhaps inevitably from investing the monopolies of public highways of communication in private interested

joint-stock companies, and once recognized and established, by granting to them large and extended lines and districts, thereby producing *ab initio* the position which the joint-stock companies of England are now seeking to obtain by amalgamation.

The writer will not here discuss the vexed question whether the granting of public railways or private companies is right or wrong; he proposes to deal for practical purposes with the facts as they are.

But whatever system is to continue, he submits that it is now full time when the whole of Germany is to be united into one Empire, that the organization of its means of communication and especially of its railways into one uniform system, and the making them as perfect both in administration of the present and the designing, laying out and construction of new lines as it is practically possible to do, should be undertaken, as being not only expected by the world from the genius of German statesmen and the talent of their engineers, but as essential—in the first degree—to the future industrial and commercial interests of the Empire, and to the establishment of those great international lines of communication which must naturally take their course through Germany owing to its central geographical position.

Similar observations are clearly applicable to Holland and Belgium, which countries will enjoy in the highest degree the first and accumulated fruits of the international communication to which this paper refers; and to Russia, Austria, Hungary, and Turkey, to the quick development of whose best interests in every respect the completion of the improved communication here contemplated would be of vital importance.

The wants of civilization and of the world demand in this age the shortest and quickest—and therefore the straightest and best—lines of communication, and all experience in railway construction tends to the abandonment of circuitous routes for those which are direct. For through-going traffic and postal communications between distant countries these principles are becoming daily more essential, and all the improvements hitherto obtained, as compared with the slow coaching of old times, only render the public more sensibly alive to the absence of that perfection in the present lines of communication of which they are palpably capable.

Notwithstanding the very great improvements made in the present year, the time occupied, for example, even with express trains between, say, Berlin and London for passengers and letters is at the shortest thirty hours, and between Düsseldorf and London twenty-two hours, (whilst the shortest between London and Düsseldorf is sixteen hours) is far too long, and can as hereinafter shewn, be most materially reduced.

The writer opines that it would be folly to hesitate for these international lines at least (if not for all passenger and postal lines) to decide that they shall be constructed and worked wherever new lines are required, or that they shall be altered in construction and worked wherever existing lines can be adopted into the system, on principles by which the mission of railways can be truly and perfectly fulfilled.

It is not expected that any experienced railway practitioner or authority will contend that this cannot be done, but many will exclaim against the additional cost or expense involved.

If it can be done, then it is contended that it is the duty of the Governments and of the Legislatures of Europe (at least as the birth-place of railways) to insist that it should be done, and done too with the least possible delay.

As regards the additional cost of construction, the writer has no hesitation in stating that he has seen as yet no place in Europe where, for such purposes as are here contemplated (provided the funds be truly devoted under judicious management to work, and not wasted in preliminaries, as in some countries, or in share and exchange speculations as in others), the necessary works for a perfect system of railway cannot be executed with results commensurate, on the whole, to the expenditure, and insisting that the first cost of a perfect system however apparently high—if confined to useful, not ornamental work—rarely fails to be remunerative, owing to the greater economy in the working for the long ages the railway has to endure.

The writer premises the above, as he anticipates there will be still found some to oppose, or at least to express alarm at the extent to which he would propose to go, in order to make these international railways as complete and perfect as it appears to him they should be for such a purpose.

For these international lines, and especially for the main trunks of the system, the railways should pass over or under every other line of communication. No level crossings of railways, roads, navigations, or even of footpaths should be allowed, and the railway should be completely fenced on both sides. The railways should be constructed with double lines in the centre for all passenger and postal trains; the passenger traffic separated from the goods and mineral traffic; arrival and departure platforms and buildings provided at the stations; no facing points allowed on the passenger lines under any circumstances, no head stations except at termini, and those constructed with abundant length beyond the arrival platform, and in short the whole construction should be

adapted for running express trains at the highest attainable speed without risk of collision, whilst sleeping carriages and all the means of living should be provided in the trains themselves for the long journeys which under such circumstances, and with such improved accommodation, would be then freely undertaken by thousands who at present prefer to remain at home.

International lines to be so worked should, as far as their earth and masonry works are concerned, be designed for four lines of rails for the greater part of their length, though of course the two additional lines would only be laid down when necessary; but there is little doubt that in a very few years a great through traffic for long distances in goods, cattle, &c., would arise, which would render these additional lines necessary and remunerative. As a general principle the main stations for such a system should, according to circumstances, not be nearer than forty to fifty English miles, and should for the passenger and mail traffic be on a high level, so that the railway should pass through or by the towns, whilst the side or goods lines should be passed under the so raised central express lines of rails, and lead to quite separate goods stations, say outside the town on the level of the country, or as nearly so, as circumstances will permit.

In the mean time, the existing crooked and cross lines of railway of the country, which would not admit of adaptation into the international system, would be abundantly occupied in the local passenger, goods, and mineral traffic of the country, and at the important fixed stations above mentioned, would join into the international lines, for the transfer of passengers, letters, and goods.

On the principles above enumerated, many great and important international lines of communication can, and, doubtless, will, soon be devised for passing through Europe in various directions. The writer's residence in the Rhine Province for eighteen years, and his personal experience of the want of improved communication, has naturally turned his attention to the connection of the steam navigation of the Atlantic through the natural entrepot of the English Channel, to the North and East of Europe, and the often mooted question of the best line of communication between England and India, and he wishes to illustrate the views he has long entertained on these subjects by the sketch of a project for international communication through the new harbour of Flushing, described in this paper, and delineated roughly on Plate XXXVII.

HARBOURS.

The first consideration was to determine on the harbour, which would be most suitable for the terminus of the international railway, and with this view the writer, at various times, visited and inspected all the harbours along the North Sea from Boulogne to the Elbe, with the exception of the Helder and Harlingen, the positions of which rendered them of comparatively little interest to the object he had in view.

The investigation of these various harbours, and the charts of the adjacent sea are full of interest to the engineer, exhibiting along this long stretch of low coast, with its peculiar delta formation the great efforts which different nations have made to contend with nature, and overcome difficulties of no ordinary kind. At the same time it opens a great field for the exercise of the talents of the engineer who carefully studies the delta forming rivers and estuaries where they exist, and who avails himself judiciously of the forces of nature, in the flood and ebb of the sea tides and the discharge of the rivers, to carry outplans in aid of nature for the improvement of harbours and the attainment of deep channels of access to them at all times of the tide.*

This is not the place to discuss such questions, or to enter into a detailed description of all these harbours. It will perhaps be sufficient for the purpose of this paper to say, that the roadstead of Flushing has ever had by nature deep water at all times of tide, and is rarely, if ever, incommoded by ice; whilst the harbours to the west, including Calais and Ostend, notwithstanding the most judicious and effective works of art there constructed, offer by nature little if any hope of ever having deep water; and the harbours to the east are either bar harbours, not accessible at all times of tide—as Rotterdam,—or are impeded by ice in winter and for the most part lie, as will be seen by the map, too far east to suit the line of international communication under consideration.

After careful study of the harbour and the marine charts, it would seem that if Flushing harbour were properly improved,—or rather, if a harbour and docks were constructed and properly connected with its own deep water roadstead,—and connected by railway with the continental net of railways, it was by nature suited, owing to its projecting position into the sea, and must necessarily become the great harbour and entrepôt of the future international communication for this part of Europe.

Holland has during the last ten or twelve years made, steadily and

* Emden is a case in point having great natural capabilities, requiring no doubt considerable expenditure, but promising great success as an efficient harbour for a large district and back country requiring such a harbour and a great maritime trade.

quietly, immense progress in her Public Works, which are executed by the State directly, in her system of State railways and great bridges constructed under very difficult circumstances,—and in her large harbour at Rotterdam and the “Hook of Holland”—in the very extensive work of the new harbour and canal at Amsterdam, all matters of considerable engineering difficulty, and all so far successfully carried out, or progressing to completion. These, taken together, afford a very brilliant example of how much a State can accomplish in that class of Public Works, which is the proper object for State expenditure, when this expenditure is judiciously made and properly controlled.

Much has been lately done at Flushing to fit it for the important position it is proposed that it should occupy. It is connected by railway with the whole continental system, and by its docks and deep water channels with the navigation of the world. It has an admirable and capacious deep water roadstead fully adequate to the commercial wants of the port at present and for some years to come, and deficient only in one respect, and that is in the size of the outer harbour in which, according to the project, the large and powerful passenger and mail steamers to and from the Atlantic, and those required for very high speed to and from England, should be enabled to come at all times of tide, day and night, without difficulty or delay—deliver their passengers and mails direct off their decks into the railway carriages, on an ample pier in the centre of the harbour, and then warping round to the departure platform at the other side of the pier, or to one side of the harbour as the case might be, hold themselves prepared to leave the harbour when necessary. For such purposes the outer harbour is too small, and even the entrance rather too confined. Plate XXXVII., shows the extensions and alterations which are considered necessary to be made in the outer harbour, and shows the central arrival and departure pier (A) for the large steamers, designed on the principle which has proved eminently successful in the harbour of Kingstown, where such a pier was constructed (by the harbour commission, of which the writer was a member,) for the arrival and departure of the mail steamers between England and Ireland.

Fortunately there is little difficulty in thus extending the outer harbour at Flushing, and it is hoped that these remarks may lead to the reservation on the part of the Government of Holland of all adjacent lands which may be required for the future extension and improvement of this important port. Nature has done everything for the roadstead to entitle it to be selected as the great terminus for this international communi-

cation, but to fulfil its mission the artificial works must be constructed, so as to admit the largest Atlantic and mail steamers as above described.

The writer has again visited the harbours, and in reply to many remarks, begs to observe as follows:—

Antwerp, with its docks extended to the north of the present docks, and the completion of the direct line of railway to Gladbach,—to the great industrial district of Westphalia—will, contrary to the fears of some, be importantly benefited in its exports and general trade by the new position which Scheldt will now take in the intercommunication of the world.

Rotterdam and Amsterdam, with their improved harbours, their direct communication by water, and their still more direct and shorter established communication by the Dutch-Rhenish railway, (and by new railways now being constructed), with the coal and iron district of Westphalia, and the middle and south of Germany, will not only maintain but increase their commercial traffic.

Finally, the industrial progress of central Europe will afford business enough for all the available and well managed harbours of the North Sea, and it only remains for all parties interested in these harbours to expedite their improvement, and increase in every possible way the accommodation to the public, for the exports and imports which the commercial necessities of the world will naturally lead to their ports and the railways terminating in them.

THE PROJECT

For international communication, which the writer takes the liberty to submit for the consideration of all interested, and as illustrative of the principles set forth in this paper, is as follows:—

The terminal harbour being once fixed, it becomes next of importance to decide upon the direction of the first part of the Main Trunk line of railway which shall best suit the diverging branches of the system it is intended to serve.

Venlo, on the frontier between Holland and Germany, is by its geographical position as well as by its relations with the existing great lines of railway, clearly indicated as the best common or medium point from which a proposed international system of communication, with Flushing for its terminal harbour, should diverge.

Venlo is, for instance, very little to the south of a direct line from Flushing to Berlin, through which will naturally pass the traffic to St. Petersburg; and very little to the north of a direct line from Flushing

to Vienna, through which will naturally pass the traffic to Constantinople and India, whilst it forms a link in the lines from the capitals of France and Belgium to the north and east of Europe.

Finally, Venlo is at present connected not only with Flushing harbour, but is also connected, or in course of being so, with all the great routes contemplated in this project, by railways, which it is proposed in many cases to utilize or adopt for the present, with the alterations proposed in the first part of this paper; and in some others (where the existing lines are more suitable by their construction for local traffic) to replace from time to time by more direct and more suitably constructed lines.

Thus, then, without much delay after the opening of the harbour of Flushing, by suitable international organization, a considerable improvement in the transmission of passengers and mails between the east and west of Europe might be effected; but to attain the speed required, and to make the system complete—to make it worthy of the great objects and the great nations whose interests are involved—it will, at the very least, be necessary to carry out the works and effect the objects described in this paper.

ENGLAND, THE ENGLISH CHANNEL, AND FLUSHING.

Assuming the outer, or entrance harbour of Flushing to be extended as proposed, to fit it for the reception of the powerful steamers referred to, then, without doubt, the time will come when the mail and passenger traffic between London and Flushing can be effected in about six hours.

The harbours of Dover and Harwich are now available for such a communication, whilst the writer has little doubt that, by suitable works, Margate could be made available for this purpose. Sheerness, Queensborough, and other points of departure within the Thames, afford ample facilities through their railway connections for passenger, cattle, and goods traffic, and will no doubt in time also be made available.

The following are distances from Flushing, to

Ramsgate	...	...	20 $\frac{1}{2}$	Prussian miles of	7407	metres, or	84 $\frac{1}{2}$	knots.
Margate	...	...	21 $\frac{1}{4}$	"	"	"	86 $\frac{1}{4}$	"
Dover	...	...	22 $\frac{1}{2}$	"	"	"	91	"
Harwich	...	...	24 $\frac{1}{2}$	"	"	"	99 $\frac{1}{2}$	"
London	...	...	36	"	"	"	146	"

One of the great advantages to Holland and Belgium, and all the nations to the east of them, is that all the passengers and mails destined for these countries from all parts of the world, which come by sea through

the English channel can be landed here and transmitted to their destinations with the least possible delay, and, of course, equal facilities can be afforded to the outgoing passengers and mails.

FLUSHING TO VENLO.

The newly-completed railway from Flushing, through the islands of Walcheren and South Beveland to the main land near Bergen-op-Zoom, is in the right direction, and can easily be increased in its dimensions and fitted with four lines of rails to suit the great main trunk line of this international system; but from Woensdrecht on the main land, where the line turns to the north to Bergen-op-Zoom, the circuitous routes of the railway to Venlo, and the local character of their construction, will call for the construction of a new, straight, main trunk line between Woensdrecht and Venlo, with a short junction to Antwerp, to ensure a direct connection to Ghent and Ostend on the one hand, and to Brussels and Calais on the other.

This straight line will pass chiefly through Holland, and for a short distance through Belgium, the commercial interests of both which countries will be so materially promoted, by having the Scheldt used as the great entrepôt of this part of Europe, that without doubt their Governments will agree to perfect this part of the proposed international communication.

It is unnecessary, here, to enter into detail as to all the passenger and postal arrangements which can be perfected in Holland and Belgium by the establishment of this communication between Flushing and Venlo; they will be self-evident to every observant person.

VENLO TO BREMEN, HAMBURG AND DENMARK.

From Venlo, the newly-constructed, almost direct line, by Wesel on the Rhine, Münster, Osnabrück, Bremen, and Hamburg approaches completion, and when regulated as above proposed, for the reception of international traffic, by the removal of all level crossings or other impediments to the safe working of express trains, will form the most suitable northern branch of this international system to Hamburg and Denmark, and all the intervening and adjacent countries, whilst on the other hand it forms a part of the most direct line from Paris to Hamburg.

The enormous advantages of the saving of time for passengers and mails by the adoption of this route and the express system proposed, requires—at least for the parties interested and resident in the cities and towns along it—no comment.

VENLO TO BERLIN AND ST. PETERSBURG.

From Venlo to the Rhine and Dortmund, in the direction of Berlin, and from Venlo to the Rhine at Düsseldorf, there exist a great number of railway lines, made by various parties, for various objects, but without any great or national plan in view, and by a strange fatality scarcely any of them suitable for the great international and express traffic contemplated in this paper.

In the great mineral district, between the Rhine and Dortmund, it is true, express trains have been recently, and are now daily running (through all the coal and goods trains, the miserably insufficient stations, and level crossings of railways and roads,) over railways suitable, now at least, only for local traffic; but this is a risk of such magnitude as nothing but the most absolute necessity and the want of a suitable line for this express traffic can justify.

Fortunately the Prussian Government has recently decided upon a most suitable site for a bridge over the Rhine, between Ruhrort and Duisburg; and doubtless Government will, with a view to the great international traffic, arrange that this bridge shall be constructed to carry at least four lines of rails, and to suit the wants of the coming future as well as the present.

For the great international traffic to Berlin, St. Petersburg, and the North-East of Europe, no petty difficulties, or narrow and mistaken views of economy, should stand in the way of the formation of the most direct and most perfect railway which can be constructed, and that in devising such a line, the wants of the future, the enormous increased traffic which that future will certainly develope, should be fully weighed and considered.

The writer's study of the country, for some years, in furtherance of this view, leads him to propose a straight line from Venlo to the proposed bridge between Ruhrort and Duisburg, and thence, in the same straight direction, through the middle of the Westphalian Coal District between Essen and the line of the Emsher valley, a little to the north of Dortmund, and a little to the south of Hamm, direct through the valley of the Lippe, and in the best practicable line through or near Detmold and Hannover to Lehrte, from which the Lehrte-Stendal line with the necessary modifications can be adopted to Berlin.

From Berlin the best existing direct railway route suited for express trains will be adopted to St. Petersburg, and the traffic to the many important intermediate places easily arranged according to the peculiar circumstances of each.

VENLO, DUSSELDORF, ELBERFELD TO MIDDLE GERMANY AND RUSSIA.

Although lines exist from Venlo to Düsseldorf which suit the present traffic, yet, for the purposes here contemplated, a direct line from Venlo to Düsseldorf, crossing the Rhine below the town, combined with a very ample harbour there, will become an absolute necessity for the greatly increasing manufactures of the district between Venlo and Hagen.

Such a line will be not only necessary for the branch to Middle Germany, but even still more for the completion of the most direct line to Vienna and Constantinople hereinafter referred to.

From Düsseldorf, the Bergish-Märkish system, with considerable alterations or a greatly improved line, can be used to Hagen and thence the Ruhr valley line and other existing railways would form the branch under consideration, but with many important ameliorations, to Cassel, Halle, Leipsic, Dresden, Breslau, Warsaw, and ultimately, no doubt, to Moscow, serving at all these stations for the east and west traffic of the great districts connected with these cities by existing railways.

VENLO TO SOUTH GERMANY AND SWITZERLAND.

The Rhenish railway on the left bank of the Rhine, which is at present connected with Venlo, will naturally take up this traffic, and, with the other existing railways, maintain the express communication with the capital towns of South Germany, Carlsruhe, Stuttgart and Munich, and with Switzerland.

The Rhenish and Hessian Ludwigs railway by Darmstadt to Asschaffenburg, will, with the Bavarian railways, as at present, serve for a considerable time for the express traffic between Venlo, Vienna, and the East ; but it is scarcely necessary to repeat that to fully adapt these existing railways for the express traffic for passengers and mails contemplated in this project, many important alterations and improvements, of the nature referred to in the first part of this paper, will be indispensable.

VENLO, VIENNA TO CONSTANTINOPLE, ENGLAND TO INDIA.

Inferior perhaps to none of the branches of this project of importance to Europe and Asia, or at least to the nations of both continents immediately concerned, is the great line of international communication designated by this title.

All authorities who have contemplated a railway communication between India and England have, almost of necessity, regarded Constantinople as a fixed point in the line ; and it will be readily seen that

Vienna, which lies nearly in the direct line between Venlo and Constantinople, becomes, even independently of other great considerations, geographically another fixed point in this part of the project.

The writer has stated above, that for the present the traffic can be carried on by the existing route, Venlo by Mayence, Darmstadt, Nuremberg, Passau, Lintz to Vienna, but even if we measure the importance of this line by considerations limited to the passenger and mail traffic of Austria, Hungary, Rumania and Turkey to Constantinople, irrespective of the more distant prospects of communication with Persia and India by the Euphrates valley, it is clear and incontestible that the most perfectly devised trunk railway should be constructed in the most direct line which the country will admit of, between Venlo and Vienna, whereby a great saving in distance and time would be effected.

Such a direct line would pass from Venlo direct to Düsseldorf, as already proposed, and thence to Siegen, and so far it is required even at present by the local wants of the district. How the straightest line can be practically made from thence to Vienna is yet to be shown; but the main points in the straight line, judging from the map, are Fulda, Beuruth and Badweis to Vienna, and there can be little doubt that a suitable line, much nearer to the straight direction than that by Bingen and Darmstadt can be found.

From Vienna the existing line to Pesth, and thence to Piski and Petroseny in the Carpathian Mountains, near the Borders of Rumania can be easily made suitable, for the extension in the desired direction of this international system.

From Pesth to Constantinople, or into Rumania, another line might be selected, as, for example, by Czegled, Szegeden, to Temesvar, and thence by the existing line to the Danube at Baziash, from which place a line has been projected to Constantinople; or from Temesvar by a line already projected, and which must, for the mineral and agricultural interests of this rich district, be constructed along the valley of the Temes to Karansebes, and thence by Mahadia near the famous and delightfully situated Hercules Baths to the Danube at Orasova, whence by the "Iron door" it could proceed through Rumania either to Varna or possibly more directly to Constantinople.

But the writer prefers the line by Petroseny because it is more direct and is already constructed and open to that town, where, at a height of 2,000 feet above the sea, it enters a stone coal district with existing collieries, worked by the "Kronstädter Verein" and the Hungarian Government (who have both established excellent colonies of workmen)

which produce an almost inexhaustible supply of admirable locomotive and manufacturing coal.

Such a supply of coal on the direct line of railway, in a country where some of the richest and purest iron ores not only exist in abundance, but are being worked in blast furnaces erected by the "Kronstädter Verein" at Kalan (where the best Bessemer steel rails can be produced), would be of almost incalculable value to Rumania and Turkey if this line were carried through, instead of stopping, as at present, at Petroseney.

Fortunately, even in this great mountain district, the little river, the Shill, which takes its rise in the coal valley referred to, breaks directly opposite Petroseney, through the mountain range, in a grand chasm, with a regular fall into the plains of Rumania, close to the so-called Vulcan Pass, which, though it may elicit all the energy and talent of the engineer (perhaps by the adoption of a combination of short tunnels and side cuttings in rock), presents in these days of engineering skill, no great difficulty for the construction of this most important line of railway.

In concluding this sketch of the railway part of the project, the writer wishes to remark that it contemplates the trunk and two of the great branches of the international communication, namely, Flushing, Venlo, Berlin, St. Petersburg on the one hand, and Flushing, Venlo, Düsseldorf, Vienna, Constantinople on the other hand, remaining in the hands of the Governments of the countries passed through; whilst the other three would be worked by private companies—namely, Venlo-Hamburg by the Cologne Minden, Venlo-Düsseldorf to Cassel, &c., by the Bergish Märkish, and Venlo-Bingen towards the south of Germany and Vienna by the Rhenish railway company, which arrangement would afford an opportunity for competition and for testing the best systems of working railways at high speed.

ANTICIPATED RESULTS.

With the deep water harbour of Flushing completed, and connected by rail with the main land,—and assuming that the simple principles of railway construction, improvement, and adaptation to the necessities of safe and quick transit referred to in this paper are adopted, so as to make these lines examples to the world, what would be the effect on the passenger and postal traffic over these international lines if properly organized and carried out?

Assuming only the rate of speed at present attained by express trains

in Germany, and express steamers between England and Ireland, it is contended that passengers and mails can be carried from—

London to Hamburg in 16 hours,	
Do.	Berlin, Dresden, or Munich, in 18 hours.
Do.	Düsseldorf, Elberfeld, or Cologne, in 10 to 11 hours,
Do.	Vienna, in 24 hours,
Do.	St. Petersburg and Constantinople, in 48 hours,

and, of course, on the return journeys in the same time.

It may also be safely anticipated, that for such a traffic through-going-trains and suitable carriages for sleeping and living will be constructed and used; that from and to the port the passenger will be made nearly as comfortable as in his own house: that the inconveniences of customs' investigations on the frontiers will be completely avoided by suitable international arrangements at the starting and arrival stations; and that, in a word, the true mission of railways as the most perfect, rapid, and safe mode of transit, will before long be fulfilled.

With reference to the proposal for extending the outer harbour or "Buitenhaven" of Flushing, the writer has received reports as to the harbours and mail service between Holyhead and Kingstown, from which the following extracted information and facts will doubtless be interesting to all concerned in developing the project herein proposed for Flushing.

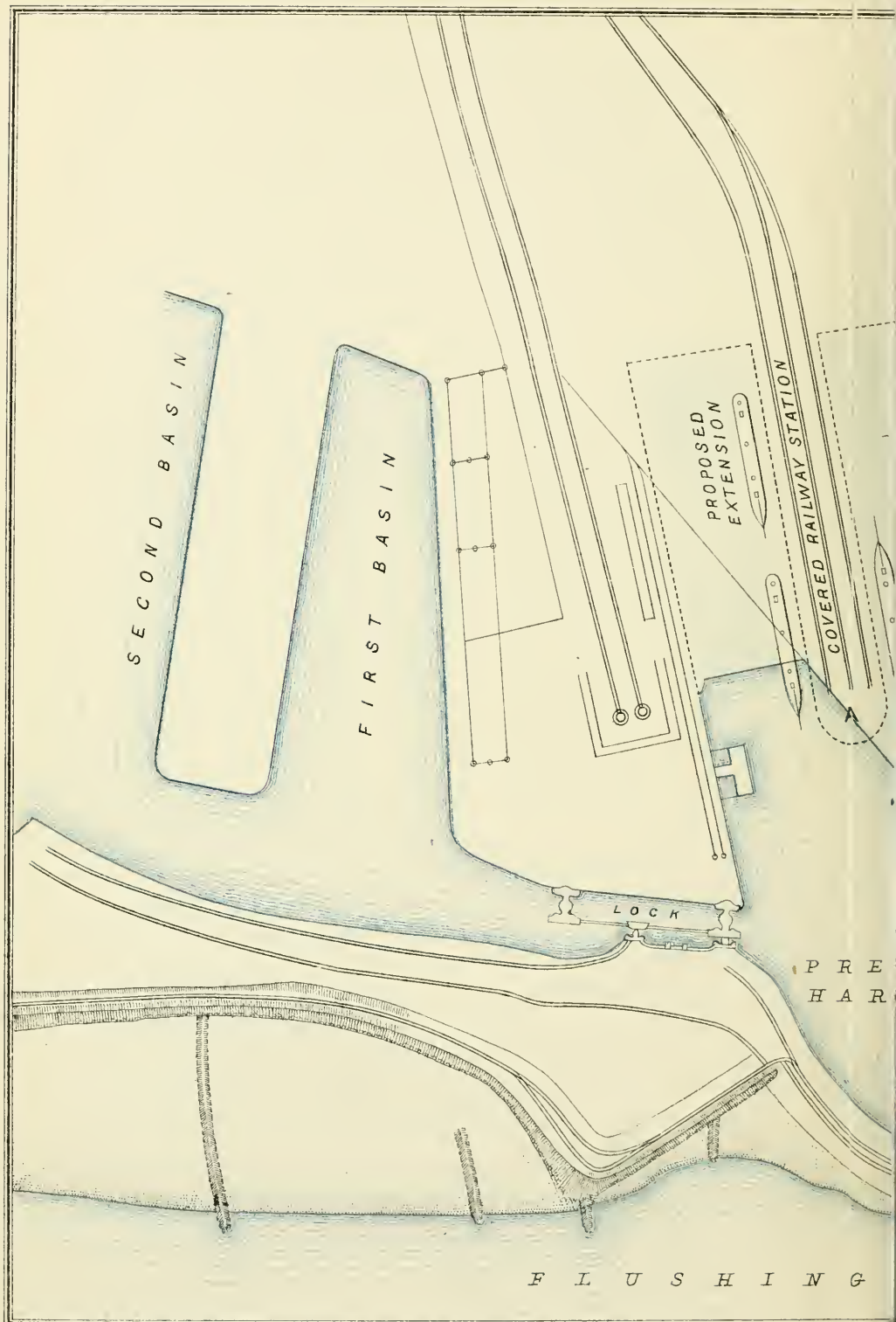
The pier at Kingstown is a free end pier (with semicircular end) it is 900 feet long, 80 feet broad, having a covered-in railway station thereon, with arrival and departure platforms, by which means the transfer of passengers, their luggage, and the mails from the steamship to the railway carriages, and *vice versa*, is effected in the most perfect order in a very short time indeed.

There is a depth of 20 feet of water alongside the pier at low water of spring tides, and steamships lie in still water.

Similar erections and arrangements exist at Holyhead.

So complete is the whole system, that the Postmaster-General of Great Britain and Ireland is enabled to contract with the railway and steamship companies, for the delivering of the mails from London to Dublin, and Dublin to London, including the sea passage in a fixed time—every day four journeys—under heavy penalties for any breach of contract as to time, extraordinary storms excepted.

For the sea voyage between Holyhead and Kingstown (about 65½ English miles between the light-houses) four splendid steamships were built by different firms nearly on one model, and the service commenced in 1860.

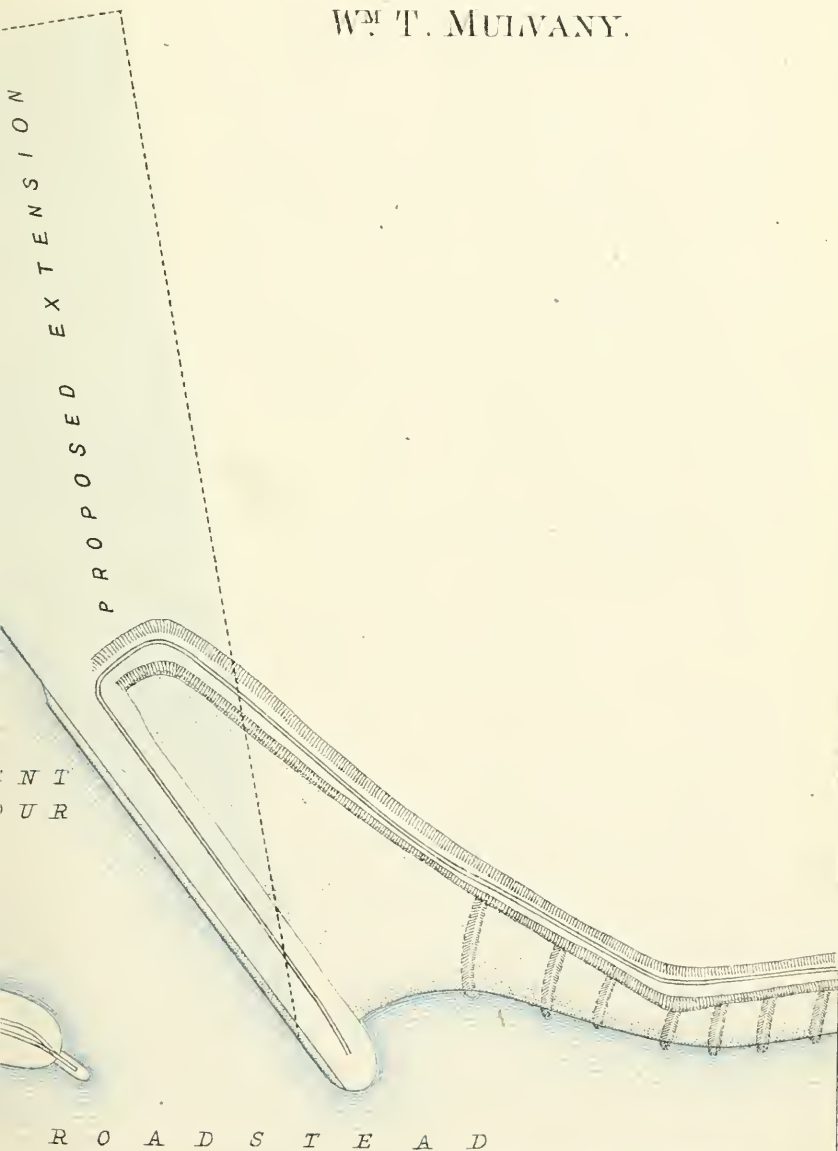


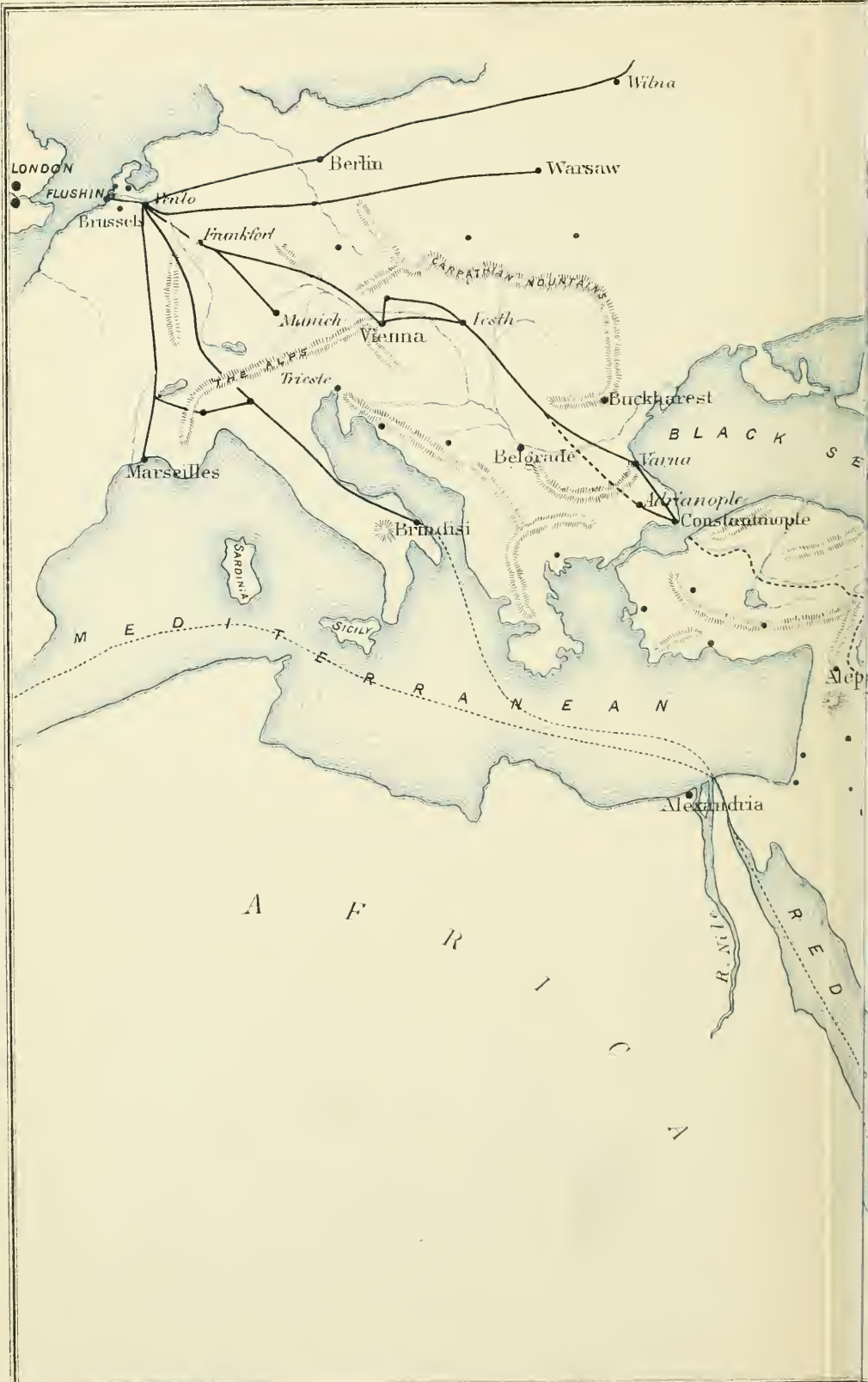
HARBOUR OF FLUSHING

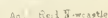
SHEWING ENLARGEMENT

as projected by

W^M T. MULVANY.







These four ships, named Connaught, Leinster, Munster, and Ulster, are each about 2,000 tons burden, have a length between the perpendiculars of 334 feet, and 35 feet breadth of beam; a depth of 21 feet, and draw about 12 feet 9 inches to 13 feet 2 inches of water. The paddle wheels are 31 feet diameter, with feathering float boards 4 feet broad and 12 feet long. The nominal horse power of the steam engines is 720 horses.

The following registry of the numbers of voyages made by these four ships in the twelve years ending September, 1872, speaks for itself as to their speed and the wonderful accuracy of the time kept by each ship respectively, during that long period.

TABLE.

AVERAGE TIME (INCLUSIVE OF ALL DELAYS FROM STORMS, FOG, ETC.) OF PASSAGES OF THE FOUR MAIL PACKETS BETWEEN KINGSTOWN AND HOLYHEAD (DISTANCE ABOUT $65\frac{1}{2}$ ENGLISH MILES) FOR 12 YEARS ENDING SEPT. 30, 1872.

	Connaught.		Leinster.		Munster.		Ulster.		Four Packets.	
	No. of Trips	Time.	No. of Trips	Time.	No. of Trips	Time.	No. of Trips	Time.	No. of Trips	Time.
Winter $\frac{1}{2}$ year	2606	h. m. s. 3 55 1	1970	3 56 5	2000	3 59 4	2169	4 1 1	8745	3 57 9
Summer $\frac{1}{2}$ year	2163	3 51 9	2323	3 51 9	2180	3 52 2	2117	3 55 9	8783	3 53 1
Whole year..	4769	3 53 6	4293	3 55 0	4180	3 55 7	4286	3 58 5	17528	3 55 4

The accuracy as to keeping time and the certainty of the voyages (in a sea exposed to much stormy and bad weather) shown by the foregoing table, can only be obtained by the means indicated, namely, deep water harbours at both ends, straight piers easily approachable in all weather and state of the tide, day and night, and powerful steamers constructed on the best principles for the attainment of high speed, combined with the safety and comfort of the passengers. .

A vote of thanks was unanimously awarded to Mr. Mulvaay, the author of the paper, and to Mr. J. A. Ramsay, the gentleman through whose instrumentality it was communicated to the members.

The meeting then separated.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, JUNE 5, 1875, IN THE WOOD
MEMORIAL HALL.

A. L. STEAVENSON, Esq., IN THE CHAIR.

The SECRETARY read the minutes of the last meeting, and reported the proceedings of the Council.

The following gentlemen were then elected :—

MEMBERS.

Mr. CHARLES E. PARKIN: Perran House, Perran Porth, Truro, Cornwall.
Mr. CHARLES JOHN BAGLEY, Tees Bridge Iron Co., Stockton-on-Tees.
Mr. ROBERT DIXON. Wire Rope Manufacturer, Teams, Gateshead.
Mr. GEORGE TAYLOR. Brotton Mines, Saltburn-by-the-Sea.
G. C. RICHARDS, M.E., Woodhouse, near Sheffield.

STUDENT.

Mr. ARTHUR MUNDEE, 7, Collingwood Street, Newcastle.

The following were nominated for election at the next meeting :—

MEMBERS.

Mr. C. G. SWANN, 52, Old Broad Street, London.
Mr. DANIEL ADAMSON, Newton Moor Iron Works, Hyde Junction, near Manchester.

STUDENT.

Mr. W. A. ROWELL, Jesmond Gardens, Newcastle-upon-Tyne.

Dr. H. Alleyne Nicholson then read the following paper “On the Mining Districts on the North Shore of Lake Superior.”

ON THE MINING DISTRICTS ON THE NORTH SHORE OF LAKE SUPERIOR.

BY H. ALLEYNE NICHOLSON, M.D., D.Sc., F.R.S.E.,

Professor of Biology in the College of Physical Science, Newcastle-on-Tyne.

IN the following communication, the writer proposes to lay before the Mining Institute a general sketch of the mining districts of the north shore of Lake Superior, which he has visited upon several occasions. It is not proposed to enter into minute statistical details, but rather to give a general idea of the position of the metalliferous areas of the mining regions in question, their chief geological features, and their present aspect and future prospects considered from a practical point of view.

Lake Superior is well known as the largest of the great chain of American Lakes ; and as its longest diameter runs east and west, it has become customary to speak of the "North Shore" and "South Shore" as forming the margins of the entire lake. The political boundary-line between Canada and the United States, after pursuing a devious course through Lakes Ontario, Erie, St. Clair, and Huron, enters Lake Superior at the town of Sault Ste. Marie at the eastern end of the lake, and should naturally have left the lake at the town of Duluth at its western extremity, Plates XXXIX. and XL. The boundary line, however, takes a northerly trend, and passing between the main land and the large and valuable island of Isle Royale, finally leaves the lake at the mouth of the Pigeon River, at a point on the north shore situated about 140 miles to the east of Duluth. It follows from this that whilst the entire "South Shore" of Lake Superior belongs to the United States, only the easterly two-thirds of the "North Shore" is in possession of the Dominion of Canada, Isle Royale and the western third of the "North Shore" forming part of the State of Minnesota.

The shores of Lake Superior are bold and rocky, and for the most part covered with primeval forest or "bush" down to the water's edge ; so that they offer little attraction to a purely agricultural population, whilst the mineral wealth has not been understood or appreciated until of late years.

For these reasons, amongst others, communication with the greater portion of the shores of Lake Superior is still a matter of considerable difficulty. On the north shore there is only a single town (Prince Arthur's Landing), a couple of Hudson Bay settlements (Fort William and Red Rock), and a few mining and lumbering stations, only one of which attains to the dignity of a village. Prince Arthur's Landing, on Thunder Bay, may be regarded as the commercial centre of the north shore, and it can be reached during the summer months by several routes, of which the easiest and most preferable are here mentioned. The visitor may, in the first instance, start from Toronto, on the north shore of Lake Ontario, and proceed a distance of ninety miles by the "Northern Railway" to Collingwood, a thriving little town at the north-eastern extremity of the Georgian Bay. Here he gets on board one of the Lake Superior steamers, which run twice a-week between Collingwood and Duluth. The trip between Collingwood and Prince Arthur's Landing occupies about three days in favourable weather, and may be regarded as an exceedingly pleasant one if not undertaken too early in the season, the accommodation on the steamers being good, and the scenery passed through in many instances highly picturesque. The above route may be varied by taking another excellent line of steamers which run from Sarnia, on Lake Huron, to Duluth, on Lake Superior, and which also ply twice a-week. It is also possible to reach the north shore of Lake Superior by means of the American Railroads, *viâ* Chicago, Milwaukee, St. Paul's, and Duluth. From Duluth the traveller proceeds by steamboat to Thunder Bay, a distance of about 190 miles. The south shore of Lake Superior is easily reached by various lines of steamers running from Chicago or Detroit to Marquette.

So far as the transportation of goods of different kinds is concerned, a large number of steamers now ply between Lake Superior and various ports on the lower lakes, and vessels of several hundreds of tons burden can proceed uninterruptedly from any point on Lake Superior to Montreal or to Quebec. When the Welland and St. Lawrence canals are enlarged, as is now being done, a considerably heavier class of vessels will be able to run, without transshipment or breaking bulk, between Lake Superior and the ocean.

During the winter months navigation on all the great lakes is completely stopped, owing to the closure of all the ports by ice. At this period of the year, therefore, no communication between the north shore of Lake Superior and the outer world is at present possible, except by means of snow-shoes or dog-trains. The times of closure and commence-

ment of navigation, as a matter of course, vary greatly in different seasons. As a rule, however, the steamers cease to run about the end of October or the beginning of November, and re-commence about the end of April or beginning of May. The port of Duluth has, however, been known to be choked with ice up to as late a period as the middle of June. As a rule, therefore, it may be considered that all traffic with Lake Superior is closed during six months of the year. This state of things, however, it is hoped, will in the course of a few years be put an end to by the construction of the Canadian Pacific Railway, with a branch line to Thunder Bay or Nipigon. It may also be mentioned that though shipment of ore is not possible during the winter months, the climate in no other way interferes with mining operations, all of which are carried on at least as actively during the winter as in the summer.

With regard to the general geological features of Lake Superior, the whole of this vast sheet of water is hollowed out of rocks of Palæozoic age. Much yet remains to be done before the geological structure of Lake Superior can be spoken of with the positiveness of detailed knowledge. Four well-marked groups of rocks have, however, been recognised as entering into the composition of its shores :—

1st.—The *Laurentian Rocks*.—The main body of the rocks of this age lies to the north of the Lake Superior, only occasionally appearing on the shore itself. The series consists almost entirely of gneiss and mica-schist, with occasional masses of syenite, but apparently without any calcareous bands. The lodes in this series consist usually of quartz or felspar, and sometimes carry the sulphides of copper, iron, lead, or zinc : but nowhere in this region have they ever been shown to contain deposits of economic value.

2nd.—The *Huronian Series*.—These rocks are largely developed on the north shore of Lake Superior, and consist essentially of greenish-grey felspathic, talcose, micaceous, or siliceous schists, with numerous interstratified traps, and occasional isolated masses of granite or syenite. The schists vary almost indefinitely in their lithological characters, and generally dip at high angles. The rocks of this series are intersected by numerous mineral veins, some of which carry notable quantities of gold and silver, along with the ores of other metals. There are also occasional bands of magnetic iron ore and hæmatite.

3rd.—The *Upper Copper-bearing Series* or *Nipigon Group*.—The rocks of this series are largely developed in the Nipigon basin and around Thunder Bay, and consist in their lower portion of beds of chert, dolomitic sandstones, and black argillaceous shales, and in their upper portion of

sandstones, conglomerates, and indurated marls, with beds of interstratified traps, and crowned by a great thickness of compact and amygdaloidal traps. The whole of the upper copper-bearing series is intersected by numerous mineral lodes, containing silver, lead, copper, &c. Two sets of lodes are recognisable, the one set striking about N.W. and S.E., or N.N.W. and S.S.E., and the other set striking N.E. and S.W. The richest of the known mineral deposits on the north shore of Lake Superior occur in the upper copper-bearing series; though it seems very probable that the mineral veins which intersect the Huronian series will ultimately prove to be at least equally rich. It is also in this series of rocks that the celebrated deposits of native copper, on the south shore of Lake Superior, occur.

The precise relationships between the upper copper-bearing or Nipigon series, and the Huronian rocks, are still a matter of opinion. The evidence afforded by the north shore would seem to show that the former repose unconformably upon the latter; but the sections on the south shore would seem to prove that the two series of rocks are conformable (Brookes and Pumpelly, *American Journal of Science and Art*, June, 1872). It seems, upon the whole, most probable that the upper copper-bearing series correspond with some portion of what we term the Cambrian formation.

4th.—The *Sault Ste. Marie Sandstones*.—These are a group of sandstones of a soft friable character, and mostly red or poikilitic, which generally have a horizontal or only slightly inclined position, and are very largely developed on the south shore of the lake. A few fossils have been found in these sandstones, but are unfortunately not such as to settle their age, which is still a matter of opinion. They have usually been regarded as corresponding with the "Potsdam sandstone," which forms the base of the Silurian series in the state of New York; but Professor Bell has suggested that they may be of Permian or Triassic age, an opinion which is certainly to some extent borne out by their lithological characters.

MINES AND MINERAL LOCATIONS OF THE NORTH SHORE.

The chief mineral deposits on the north shore of Lake Superior that have hitherto been worked, or which promise to prove of permanent value, comprise silver, gold, lead, nickel, iron, and the ores of copper. Native copper is present in considerable amount in Isle Royale, which geographically belongs to the north shore, but the writer is not aware that it has hitherto been found in workable quantity on the Canadian side of the boundary line. In the following brief account of some of the chief existing

mines and mineral properties on the north shore of Lake Superior, his remarks refer almost entirely to locations as to which he can speak from direct personal knowledge :—

1.—*Silver Islet Mine.*—By far the most celebrated mine at present existing on the north shore of Lake Superior is the so-called “Silver Islet Mine.” Silver Islet lies just outside the easterly entrance of Thunder Bay, is overlooked by the beetling precipices of Tunder Cape, and was discovered in the year 1868. When first found, and in its natural condition, it was simply a little mass of rock, about 75 feet long, rising six or eight feet above the level of the lake, and situated about half a mile from the main shore. Though discovered in 1868, and known to contain a well marked argentiferous lode, no systematic mining operations were undertaken till 1870, and the history of the Islet is far from creditable to the foresight and energy of the Canadians. The Islet belonged originally to a Canadian Corporation, the “Montreal Mining Company,” and desultory workings were carried out in the autumn of 1868 and the spring of 1869, by this company, with the result that a quantity of exceedingly rich silver ore was taken out, and the value of the vein conclusively proved. In the face of these admitted results, and apparently influenced by fear of the practical difficulties connected with the working of the lode, the Montreal Mining Company, in the summer of 1870, sold the whole of their extensive properties on the north shore of Lake Superior, including Silver Islet, to certain American capitalists for the sum of twenty-five thousand pounds. The Americans, with characteristic energy, immediately commenced work, and having considerably enlarged the Islet by crib-work, were enabled to begin actual mining in October, 1870. Before navigation had closed, that is to say before the middle of November, 1870, they had actually shipped from Silver Islet, ore which yielded over twenty-one thousand pounds worth of silver; thus, in the first two months of work, very nearly paying the price which had been given for the whole of the lands owned by the Montreal Mining Company on Lake Superior.

From this time onwards the history of Silver Islet has been one of uninterrupted success, in spite of the quite exceptional practical difficulties and the equally exceptional expenses connected with the working of the mine. The area of the Islet has been increased by strong and expensive crib-work to two acres, and more than a dozen good buildings have been erected on it; whilst a thriving mining village, with extensive docks, a church, school, &c. has been erected on the main shore. The number of men employed is between a hundred and a hundred and fifty, and they are carried backwards and forwards between the Islet and the main-land

by tugs. On more than one occasion, large portions of the crib-work have been carried away by the furious storms which rage in Lake Superior in autumn and spring, thus causing great expense to the company. The difficulty of working the mine was also much increased by the fact that there was only room to sink a single shaft.

Upon the whole, few mines have ever been worked under greater difficulties, or have had greater disadvantages and expenses imposed upon them by their peculiar position. In spite of all this, however, the main shaft in 1874 was down to a depth of over three hundred feet below the level of the lake, and between the autumn of 1870 and the spring of 1874 ore yielding more than a quarter of a million sterling had actually been shipped from the mine. It should be added in connection with this that the Silver Islet ore is sent from the mine to the Wyandotte Smelting Works in Michigan. There are thus heavy charges for transport, and the cost of smelting itself appears to be exceptionally and very unnecessarily high. At present, only the richer qualities of ore are shipped to Wyandotte, as these alone will repay the expense of freight and smelting, but large quantities of low-class ore have been accumulated on the Islet, and it is purposed to render these available by the erection of smelting-works on the main shore. Should this be carried out, the expenses of the company will be very materially lessened.

The sketch (see Fig. 2, Plate XXXIX.) is taken from an interesting paper on the Lake Superior Mines, by the writer's friend, Mr. P. McKellar, of Fort William, and is a section of the Islet along the strike of the vein, showing the extent of the underground workings up to February, 1874.

The Silver Islet lode is situated in rocks of the age of the upper copper-bearing series, and crosses the island in two branches, which are about twenty feet apart, and from four to six feet in width. The lode strikes about N.N.W. and S.S.E., and its hade is nearly vertical. The vein-stuff consists mainly of calc-spar, and occasionally of quartz; and the silver, instead of being disseminated through the mass, is mostly confined to a streak which varies from two inches to a foot or more in width. The silver occurs sparingly in the form of sulphide, but mainly in the native form, usually in dendritic growths or threads. Besides the silver, the vein-stuff also contains a good deal of granular galena, and occasionally zinc-blende, with small quantities of nickel and cobalt. Fine specimens of the ore are almost unequalled in richness, assaying as high as between one and two thousand pounds to the ton. The Silver Islet lode has been traced on the mainland, where it is large and well-defined, and carries galena and zinc-blende. So far, however, the result of trial-shafts has

not been such as to raise any sanguine expectations about the prospects of the vein in its extension northwards.

2.—*Thunder Bay Mine*.—Leaving Silver Islet, a sail of sixteen miles brings the visitor to Prince Arthur's Landing, a thriving little town on the north shore of Thunder Bay, the present terminus of the "Red River Route," and the centre of the whole mining region. In the immediate vicinity of Prince Arthur's Landing, or within a few miles of it, are several old or new mines, some of which deserve more or less notice. The first of these is the so-called "Thunder Bay Mine," situated about five miles from Prince Arthur's Landing, and about three miles from the mouth of the deep and rapid Current River. The lode was discovered in the year 1866 by Mr. Peter McKellar, and its superficial characters warranted the most sanguine anticipations. It cuts through rocks of the age of the upper copper-bearing series, having a N.N.W. and S.S.E. direction, and it varies in width from twelve to twenty feet, the vein-stuff being quartz, enclosing large masses of the country-rock. At the surface the ore was extremely rich, containing large quantities of native silver, and silver-glance, with some galena and zinc-blende. A company was formed to work the vein, the shares being mostly taken in England; and a good deal of expense—which might well have been spared—was incurred in erecting a fine stamping mill at the mouth of the Current River, in making roads, in building a dock, and in other preliminary matters. Three shafts were sunk, and a depth of between sixty and seventy feet had been reached, when the vein apparently "gave out," and all operations were stopped. Nor has any attempt been made subsequently to continue sinking. It is difficult to get at the exact details of matters of this kind, but the writer is satisfied that the view promulgated by Mr. Peter McKellar, an experienced mining geologist, is correct—namely, that the vein had been pinched out in that particular place in consequence of passing from the harder superficial strata (dolomites and beds of chert) into the much softer strata beneath (black shales), and that it would certainly be found at a greater depth to resume its original strength and richness. The total depth actually proved by sinking was very trifling, and the amount of money expended in actual mining operations was extremely small, whilst the attempts made to recover the vein appear to have been of a far from scientific character. Upon the whole, therefore, both from what he saw himself, and from what he gathered from others competent to judge, the writer would conclude that the Thunder Bay Mine may yet rival, or even surpass, Silver Islet, if a sufficient amount of capital and energy be devoted to its development.

3.—The *Shuniah or Duncan Mine*.—The Shuniah Mine—so called from “Shuniah,” the native Indian name for money—is situated about three and a half miles to the north-east of Prince Arthur’s Landing, from which it can be reached by a good road. The vein, like the two preceding, intersects strata belonging to the upper copper-bearing series, but its strike is nearly east and west, and its hade is nearly vertical. Its width is on an average not less than twenty-two feet, and it is composed almost wholly of coarsely crystalline calc-spar. Like almost all the Lake Superior veins, it is of a brecciated character, and contains numerous fragments of the country-rock. Here and there are immense “vugs,” containing many fine minerals, amongst which huge crystals of dog-tooth spar, and fine specimens of green fluor spar are conspicuous. The metallic contents of the lode consist mainly of iron-pyrites, galena, zinc-blende, native silver, and silver-glance; the three latter being usually associated with one another, and being irregularly and locally distributed throughout the vein-stuff in the form of small bunches. The vein has been proved by trial-pits over a distance of over half a mile, and a considerable sum of money has been spent in its development. The main shaft was down last spring to a depth of over one hundred and seventy feet, and silver has been found at various points in its course, some of the ore being exceedingly rich. So far, however, it is understood that the mine has not proved a remunerative undertaking; and its prospects, owing to the great width of the lode, are not as favourable as in the case of some of the other known veins.

4.—The *Silver Harbour or Beck Mine*.—This mine is situated about fourteen miles to the east of Prince Arthur’s Landing, on the north shore of Thunder Bay; and its history is almost precisely the same as that of the Thunder Bay Mine, the physical features of the two being very similar. The Silver Harbour vein intersects strata of the age of the upper copper-bearing series, and bears about E.N.E. and W.S.W., with a nearly vertical hade. The lode is brecciated, and the gangue consists mainly of quartz, with more or less admixture of iron-pyrites, zinc-blende, and galena. Near the surface, the vein cuts through beds of banded chert and dolomites, and here it has a width of from eight to ten feet, and contains considerable quantities of silver-glance and native silver, these, however, occurring in bunches and streaks. At a distance of about thirty feet the lode passes into softer argillaceous beds, and becomes extremely irregular. A good deal of money was spent in commencing to work this lode, but the mistake was committed of mining at the surface instead of sinking, and operations were suspended two years ago.

5.—The *3 A Mine*.—About a mile and a quarter to the north-east of

the Silver Harbour Mine is situated the so-called 3 A Mine. This mine is especially interesting in the fact that it is situated in the Huronian rocks, whereas all the other silver mines on the north shore of Lake Superior (with one or two trivial exceptions) are situated in the rocks belonging to the younger formation of the upper copper-bearing series. The 3 A lode strikes about E.N.E. and W.S.W., in conformity with the general strike of the stratified rocks of the district, and it intersects a series of diorites and greenish-grey slates. It has been traced for a distance of nearly a quarter of a mile, and possesses well defined, slicken-sided walls, so that there can be no doubt as to its being a genuine "fissure-vein." The lode varies in width at the surface from six to eighteen inches, the hanging-wall being an exceedingly indurated slate, whilst the foot-wall is a fine-grained greenish diorite. The hade of the vein is nearly perpendicular, but with a slight inclination to the north. The vein-stuff is brecciated, and consists of quartz, often amethystine, with a considerable intermixture of calc-spar in places, and with more or less of iron-pyrites and galena. There are also extremely rich bunches of ore, containing native silver, sulphide of silver, gold, and copper-nickel. The silver is present in very large quantity in some specimens, and picked examples would assay about a thousand pounds sterling to the ton, or even more than this. In similarly picked specimens, the value of the nickel, as yielded by actual assay, is about £200 per ton, calculating the price of nickel at about six shillings per lb.; whilst the amount of gold would be about £80 per ton of ore. It would thus appear, as the result of several analyses, that picked ore from the 3 A lode would be worth £1,280 per ton, or thereabouts. In the face of these undeniably truthful results (obtained by the United States Mint, and by the writer's former colleagues, Professors Chapman and Croft, of Toronto), the 3 A Mine has hitherto not proved a commercial success; and the reasons for this are not far to seek. These reasons—without entering into special details—are, *firstly*, that the vein is irregular in thickness, and that the rich ore is capriciously distributed in bunches; *secondly*, that the operations hitherto carried out by the proprietors of the mine have been altogether insufficient to prove its character, none of the shafts having been sunk to a greater depth than one hundred feet; and, *thirdly*, that the mine was very much overstocked in the first instance. If scientifically and systematically worked, however, there is not the smallest doubt but that the mine would prove a remunerative undertaking.

6.—The *Silver Lake Locations*.—There are many other argentiferous lodes already known to exist on the north shore of Lake Superior besides those which have been mentioned; but the writer does not speak of these in

this place, either because he has no direct personal knowledge of their characters, or because they are still in an undeveloped condition. He may, however, give a short account of a mineral property which he had the opportunity of examining the summer before last, and which presents some phenomena of special interest. The property in question consists of three mining locations bordering on the little sheet of water known as Silver Lake, which is situated about midway between Thunder Bay and Black Bay, in the Township of Mac Tavish, on the north shore of Lake Superior. Nearly in the centre of Location I. is a great mass of stratified hæmatites, intercalated amongst siliceous and argillaceous beds belonging to the "upper copper-bearing series." These hæmatites are beautifully bedded, and strike about N.N.E. and S.S.W. Portions of the mass are more or less impure, containing a greater or less proportion of earthy matter with occasionally nodules or strings of chert; but the central portion is a thick bed of exceedingly pure and fine hæmatite ore, roughly bedded, and apparently almost or altogether free from any intermixture of extraneous matter. This mass of ore is splendidly displayed at the surface, where it is beautifully polished and striated by glacial action. Owing to the fact that the entire location is heavily timbered, it was not possible at the time of the writer's visit to estimate accurately the thickness of these beds; but it may be safely concluded that the entire thickness of the ferruginous strata was about 200 feet. This conclusion has been shown to be about correct by some stripping of the ground which has since been carried out with a view to mining operations. The dip of the ferruginous beds varies from 15 degrees or 20 degrees to as much as 40 degrees or 50 degrees. The results obtained by analysis of the ore (not of picked specimens) proved these hæmatites to be of extraordinary richness and purity. The amount of metallic iron ranges from 68·88 to 69 per cent. in different samples, leaving only from 1·12 to 1 per cent. of foreign matter to be accounted for. The ore has also the great advantage of being entirely free from sulphur and titanous acid, and in containing a merely infinitesimal quantity of phosphorus.

Locations I. and II. also carry large and extremely promising deposits of lead. Those which the writer examined personally consisted of two well-defined lodes of calc-spar and quartz situated about 100 yards apart, and about six feet wide each. Both of these lodes carried a large quantity of galena, average specimens yielding by assay from sixty to sixty-six per cent. of metallic lead, and the quality of the ore would almost certainly improve below the surface. Following these lodes westwards they appear to join, and run into an immense vein-mass, about 250 feet in width, composed of

quartz with included masses of the country-rock, and having more or less of iron-pyrites, galena, and zinc-blende disseminated through it, along with small veins of heavy-spar. This large vein is undoubtedly situated on a line of fault.

Finally, in Location III., there is a well-defined copper lode, striking about E.N.E. and W.S.W., and intersecting indurated marls belonging to the upper copper-bearing series. The vein-stuff is penetrated by numerous strings and irregular masses of carbonate and sulphide of copper, but the lode was not sufficiently uncovered at the time of my visit to allow of my forming a very accurate opinion as to its extent.

The three mineral locations just spoken of comprise altogether about 730 acres, and they constitute one of the most promising mineral properties on the north shore of Lake Superior. The hæmatite is present in extraordinary quantity and of quite exceptional quality, and there are no sufficient reasons why it should not be worked to a profit. The iron-deposits are situated about five miles from the shore of Thunder Bay, the intervening country being flat, and readily admitting of the construction of a tramway. Once brought down to the water, the ore could be shipped directly either across the lake to the great iron-smelting region of Marquette, or by uninterrupted water-communication to Milwaukee, Chicago, Detroit, or Buffalo, or, if desirable, to Montreal. Nor, indeed, does there seem to be any insuperable difficulty in smelting the ore upon the spot by means of charcoal. The lead-deposits, also, promise to prove extremely valuable, the supply of good ore being apparently almost unlimited, whilst there is a reasonable probability that these lodes would be found on sinking to contain the precious metals. This, at any rate, has been proved to be the case in other similar lodes in the immediate neighbourhood, and in the same formation.

7.—The *Auriferous Lodes of Shabandowan and Jack-Fish Lake*.—In conclusion the writer would briefly notice certain auriferous lodes which have been discovered in a region lying near Lake Shabandowan and Jack-Fish Lake, and some of which he had an opportunity of examining in the summer of 1872. The region in question lies about seventy miles to the N.W. of Prince Arthur's Landing, and, pending the construction of the Canadian Pacific Railway, is not reached without some difficulty. Starting from Prince Arthur's Landing, the traveller is conveyed by wagon along the "Dawson Road," which is the commencement of the "Red River route," for a distance of about 47 miles. This brings him to the foot of Lake Shabandowan, a beautiful sheet of water about 28 miles in length, and of a width of usually two or three miles. Here a small steamer conducts him

to the Kashaboivi Portage, a point about ten miles from the head of the lake, and from that point the journey must be completed by birch-bark canoe and on foot. The whole of Lake Shabandowan is hollowed out of rocks belonging to the Huronian series, consisting of a vast series of bedded traps and greenish slates, the latter often more or less of a talcose character. The strike of the Huronian beds is usually about E.N.E. and W.S.W., and they are intersected by numerous metalliferous lodes, which generally conform in direction with the strike of the beds. Those which were specially examined varied in thickness from two to four feet, and consisted uniformly of quartz, with larger or smaller quantities of copper-pyrites scattered through it. Assays show that these veins contain gold to the extent of from £5 to £20 to the ton, but it is only very rarely that free gold can actually be detected by the eye in the vein-stuff. On the contrary, the gold appears to be disseminated through the copper-pyrites in particles too small to be made out by a hand-lens.

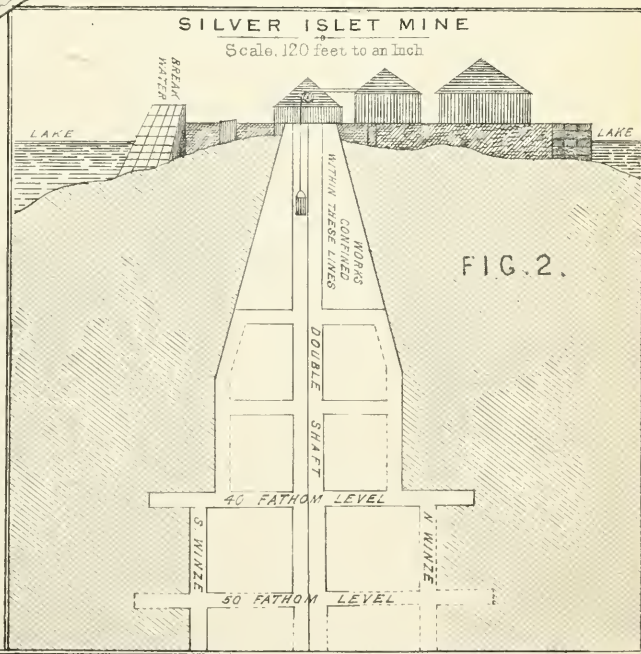
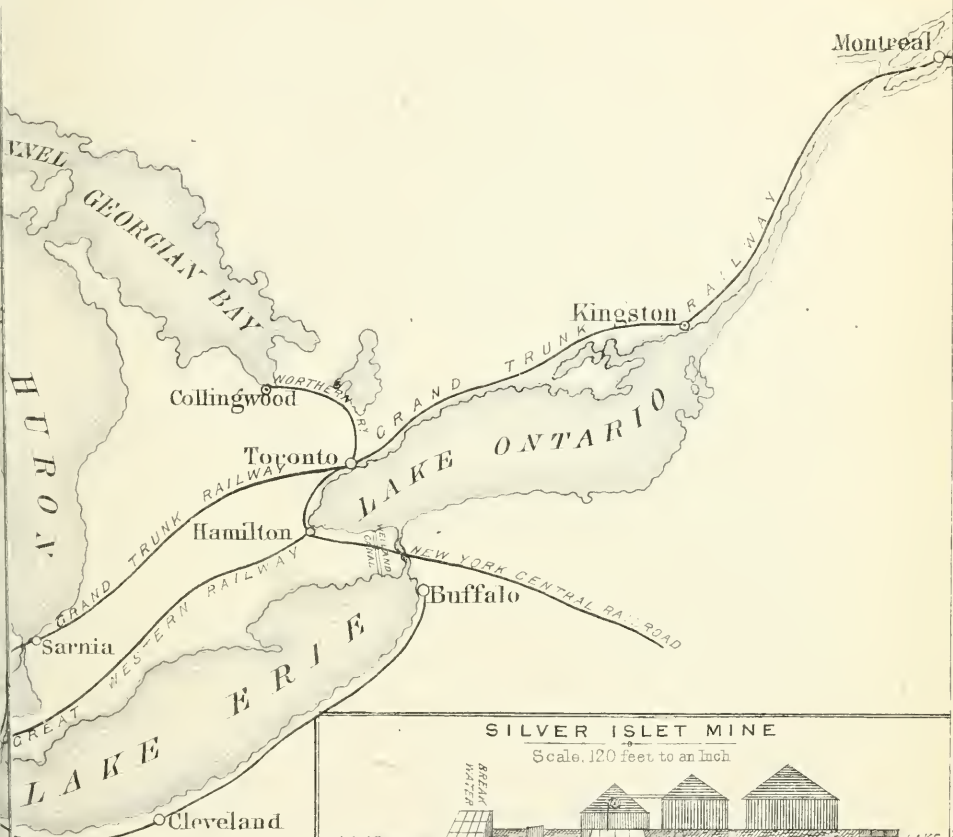
About thirteen miles westwards of the head of Lake Shabandowan, in the neighbourhood of Jack-Fish Lake, is situated a large and important auriferous lode, usually known as the "McKellar Vein." This vein intersects slates and diorites belonging to the Huronian series, and has an average width of seven or eight feet. The vein-stuff consists of quartz, and is richly metalliferous, containing copper pyrites, iron pyrites, galena, zinc-blende, sulphide of silver, free gold, and a notable quantity of tellurium. Assays have proved the vein-stuff to yield about £100 worth of the precious metals to the ton, the great proportion of this being derived from the gold, and only a small proportion from the silver.

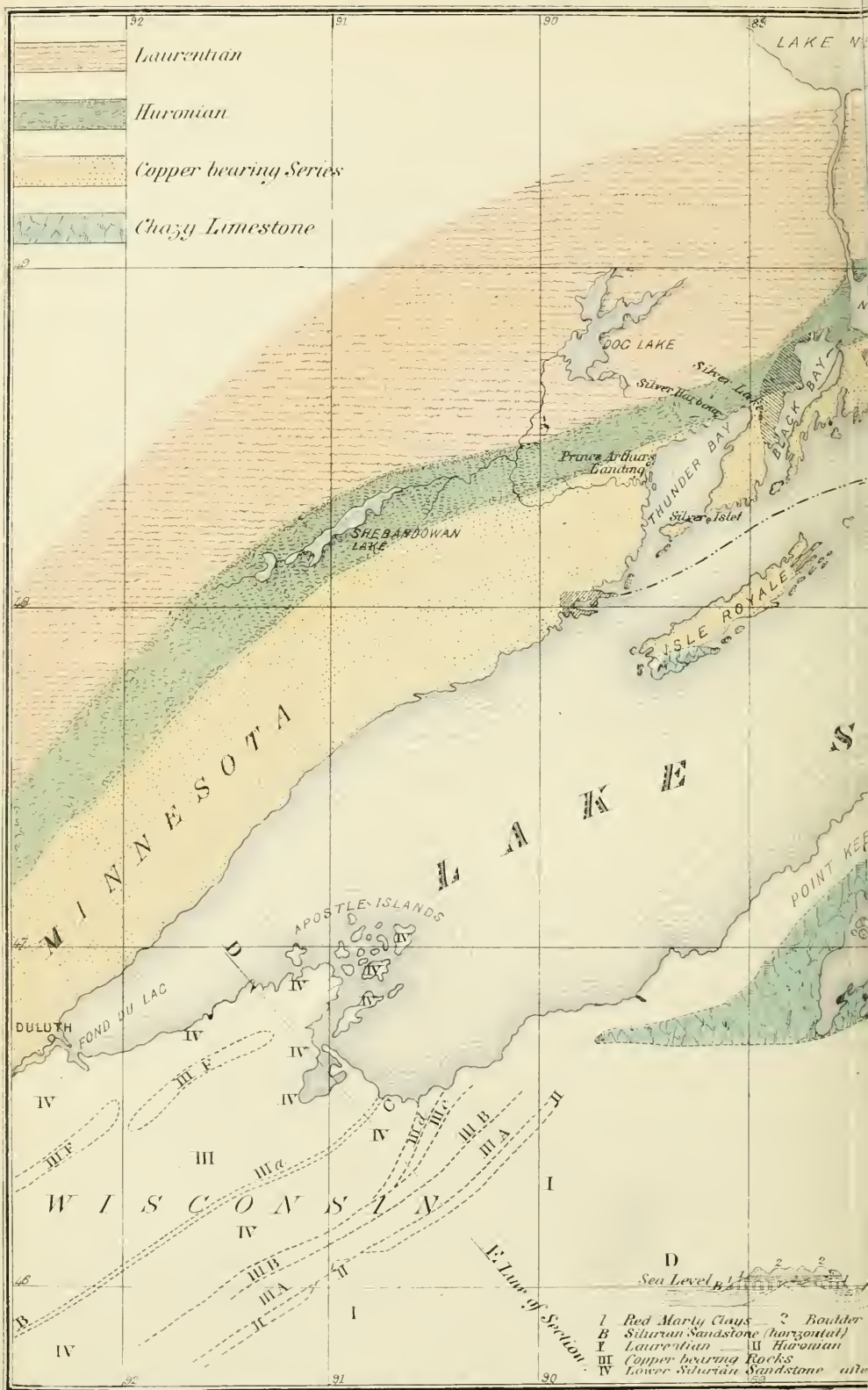
Very little has hitherto been done in the way of developing the auriferous deposits just spoken of, partly because the difficulties of transport are still very great, and partly because it is only quite lately that the district has been finally acquired from the Indians by the Canadian Government. There is no doubt, however, but that this region will ultimately prove very productive when fairly opened up.

Mr. W. COCHRANE said, he had not heard the whole of the paper read, but he had been in Canada, and he would like to ask whether Professor Nicholson had studied the commercial question of being able to produce iron on the spot, with charcoal as a fuel, and that at a profit, which, he believed, was the great point which had not been established. When he was in Canada he made enquiries, and he found that the only way was to bring all the iron down from Lake Superior; and he believed it

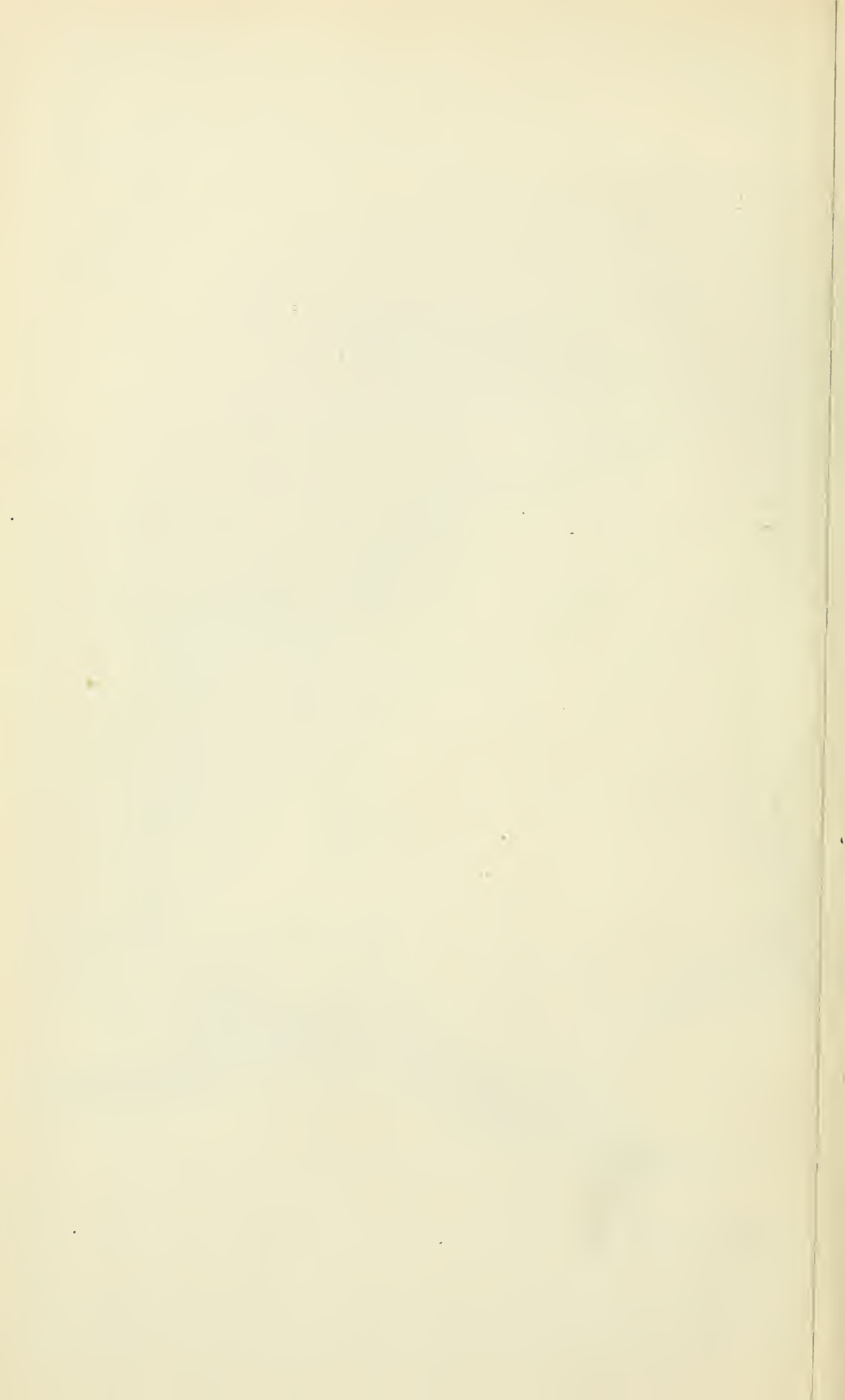


SKETCH-MAP
SHOWING THE RELATIONS OF THE
LAKE SUPERIOR MINING REGIONS,
TO THE
INLAND NAVIGABLE WATERS.
AND
CHIEF RAILWAY LINES OF CANADA
AND THE
UNITED STATES.









was a fact that at the present time the existing Government was taking steps to prevent the use of timber to the extent that would be necessary in the system which Dr. Nicholson had mentioned, namely, the production of charcoal iron, by restricting the use of the forests. He thought that Dr. Nicholson, in saying there was an unlimited supply of timber, did not know the absolute fact on this point, that as the consumption of timber was so enormous they were beginning to be frightened about their forests, and the expense in consequence of going into the interior to fetch the timber was making it a very serious matter indeed as to the economical use of it.

Dr. NICHOLSON said, Mr. Cochrane was quite correct about the timber; it was pine Mr. Cochrane was alluding to. The districts of red pine and white pine in Canada had been so reduced that, undoubtedly, unless very strong measures were taken, the timber forests of Canada would be absolutely defunct in the course of twenty years. As Mr. Cochrane said, many of the good trees had been destroyed, and they had to go further and further every year into the interior, so that it had become difficult to supply the wants in Canada itself. But he did not think that for smelting iron they would use the kind of timber that was used for the timber trade. In many parts of Lake Superior, forests, occupying thousands of square miles, contained hardly a single red or white pine. They consisted chiefly of spruce, tamarack, hemlock, birch, &c., which were useless for timbering purposes generally, but could be perfectly well employed in the manufacture of iron. He did not pretend to be an authority on the the commercial aspect of using charcoal for the purpose of smelting iron; but his colleague, Professor Chapman, had studied the question more than he had, and he had always been strongly of opinion that it could be done at a profit.

Mr. COCHRANE said, at the Hull Mines, near Ottawa, he knew it was abandoned because it could not be used at a profit.

Dr. NICHOLSON—Yes, but the largest quantity of iron they ever made in a year was a thousand tons, and he did not think they could expect that to pay.

Mr. COCHRANE said, he was certain, from the little of the paper that he heard after he came into the room, that it must have been a very valuable one, and contained a great deal of the personal observation of the Professor; and he had great pleasure in proposing a vote of thanks to Dr. Nicholson for his valuable contribution to the Society, which was unanimously carried.

The discussion on Mr. Theo. Wood Bunning's paper on "The Present Form of Marine Engine used in the Commercial Navy of Great Britain," was then proceeded with.

Mr. W. BOYD said, he thought it would be extremely advisable to adjourn the discussion on Mr. Bunning's paper. They had had the volume in their hands for only a very few days, otherwise he felt sure there would have been a large attendance of mechanical members, and they would have had a very interesting discussion on the paper, which was full of matter for a very interesting debate. He thought that if Mr. Bunning would hold over any additional remarks which he had to make until a further meeting, it was possible for the council to arrange to find a place for the discussion on some future day.

Mr. BUNNING said, he would be very happy to meet the wishes of the meeting in any way.

Mr. COCHRANE said, that after what Mr. Boyd had remarked, he thought the paper had better be made a prominent subject of discussion at the next meeting before any papers were read.

Mr. BOYD said, they must take his opinion for what it was worth. They would remember when the paper was announced in the first instance, there was a considerable attendance of engineers, and a considerable amount of interest was shown. He was sure that the paper was so good in itself that the discussion could not fail to be interesting. He would not like the arrangement to be made upon his assertion merely; but that was his own feeling in the matter.

Mr. BUNNING said, he would like to make one remark to-day. The question of whether these compound engines could be successfully used for winding was mooted in the paper, and he had drawn up a few figures to further illustrate this proposition; and as this additional matter if given to-day would probably be published before the discussion could come on, it might assist in the discussion of the question of compound engines being used for winding.

Mr. BOYD thought it a very good idea; and if Mr. Bunning could publish any additional information, by all means let it be included.

Mr. BUNNING stated that he would endeavour to make a comparison of three modes of drawing coal—

- 1st, by a single Crowther engine;
- 2nd, by a pair of horizontal engines;
- 3rd, by a single compound engine.

There are two efforts a winding engine has to make, supposing the rope to be balanced :—

1st.—It must be powerful enough to rapidly overcome the *vis inertia* of the load.

2nd.—It must be able to bring the coal rapidly to bank after the first effort of overcoming the *vis inertia* has been made.

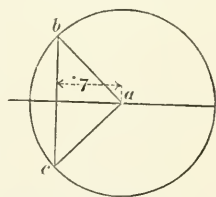
In all the cases let the drum be taken at 24 feet diameter, and the stroke of the engine at six feet.

First mode, by a Single Engine.—If the engine is so arranged that it takes its first lift at half-stroke, the engine will have a leverage of $\frac{24}{6} =$ four to one against it; and as the usual pressure on colliery boilers is about 30 lbs. per square inch above the atmosphere, with an outside available pressure on the piston of about 24 lbs. per square inch, therefore $\frac{24}{4} = 6$ lbs., the weight each square inch of piston would statically balance in the shaft.

In running, the leverage becomes six instead of four to one against the engine, for the drum takes up 3×24 feet of rope; and the engine only makes 6×2 feet of stroke per revolution, while the average pressure on the piston would not exceed 18 lbs. per square inch; therefore, each square inch of piston would, when running, only balance $\frac{18}{6} = 3$ lbs. in the shaft.

Second mode, by Two Engines.—If one of these engines is at right angles at the commencement of the lift, it is evident that it can obtain no assistance from the other, which will be on its dead centre, and therefore if the united area of the pistons is equal to that of the single piston, there will only be one-half the power available for the first lift.

But the most advantageous position for these engines to be in at the lift will be *a b*, *a c* in the sketch. Both cylinders will then be in a position to give out their power, but only to the extent of .7 of that which they would have were both at right angles.



In this position each square inch of the united area of pistons would balance as above, only $\frac{24}{4} \times .7 = 4.2$ lbs., whilst the subsequent effect in running, per square inch of pistons, would be the same as with the single engine.

Third mode, with a Compound Engine.—Steam in boiler 70 lbs. above the atmosphere, of which 50 lbs. could be readily made available in both cylinders, proportions of cylinders 3.4 to 1, that is, each inch of the united

area of both pistons to be made up of $\cdot77$ inches if large, and $\cdot23$ inches if small piston ; average indicated pressure in large cylinder 9 lbs., and in small cylinder 31 lbs.

Now if the compound engine is arranged to commence the lift when the large engine is at right angles, its power over the load will be $\frac{\cdot77 \times 50}{4} = 9\cdot6$ lbs., which can be balanced in the shaft, while for running purposes its power is $9 \text{ lbs.} \times \cdot77 = 6\cdot93$ comparative average pressure on large piston plus, $31 \text{ lbs.} \times \cdot23 = 7\cdot1$ comparative pressure on small piston, *i.e.*, $6\cdot9 + 7\cdot1$, or 14 lbs. per inch of the united area of both pistons, which would balance $\frac{14}{6} = 2\cdot33$ lbs. in the shaft.

The following table will sum up the comparisons between the engines :—

		Single Crowther.	Double Horizontal.	Compound.
At lift	...	6	4·2	9·6
Running	...	3	3	2·33

This seems to show that the compound engine would have most command of the load at the commencement of the lift, and the horizontal the least, while the compound is slightly deficient in running power ; but whether its great superiority at the commencement may not more than counterbalance the deficiency afterwards is a matter that will require future consideration.

With regard to first cost the expense of the compound engine, which in itself would be somewhat more than the single or horizontal engines requisite to do the same work, would be more than compensated for by the much smaller amount of masonry that would be required.

The old Crowther engine is simple and inexpensive, but it requires a very large house, and the strain comes upon the masonry of the walls at a considerable height from the base of the foundation ; the expense of the house is therefore very great.

With horizontal engines the elevated and solid engine-house is dispensed with, and the strain is on the foundation where it ought to be, but the foundation extends in one direction a great distance outside the drum to support the cylinders and foundation plates, and is in consequence very massive. The engine-house is also very large, although it can be constructed of either wood or brick, and need not be either expensive or substantial.

With the compound engine the foundation is all massed round the point of strain, and can be much reduced in size, and is therefore much

less liable to unequal settlements which are so often the cause of the broken bed plates of horizontal engines. The engine-house can be made of wood or some inexpensive material, and need be no larger in its ground area than the Crowther engine-house.

The meeting then adjourned with the understanding that the August meeting should be especially devoted to the discussion of Mr. Bunning's paper.

P R O C E E D I N G S .

ANNUAL MEETING, SATURDAY, AUGUST 7, 1875, IN THE WOOD
MEMORIAL HALL.

SIR W. G. ARMSTRONG, PRESIDENT, IN THE CHAIR.

The election of officers for the ensuing year was proceeded with. Messrs. J. G. Benson, J. Wallace, W. H. Hedley, and Frederick Gosman being appointed scrutineers of the voting papers.

The SECRETARY read the minutes of the last meeting, which were confirmed and signed, together with the proceedings of the Council, which were also agreed to.

The reports of the Council and Finance Committee were then read.

The PRESIDENT complimented the meeting on the extremely satisfactory reports which had been read, and proposed that they should be adopted.

Mr. A. L. STEAVENSON, in seconding the adoption of the reports, stated that it had occurred to him that, notwithstanding the great prosperity which had attended all the movements of the Institute, they might yet make themselves more useful and more prosperous by periodically visiting works of interest in the neighbourhood. He did not suggest that they should go to any great distance, or that the excursions should at any time exceed the limits of a day, but he thought that within such limits there would be many new arrangements and works of interest to members of their profession which it would be well to visit. The subject was more particularly pressed upon his attention at this time from his having met at Leeds several members of the Staffordshire Institute who were inspecting the works of Messrs. Fowler and Company, together with the exhibition now open in that town. He thought also that the

time had arrived for reconsidering whether it might not be advantageous to change their day and hour of meeting. So many of their members had now to be in Newcastle to attend Coal Trade meetings both on the Fridays and Saturdays, that he thought it possible some other day might be more suitable, and he would wish the subject to be fully considered by the Council.

The following gentlemen were then elected members :—

MEMBERS—

Mr. G. C. SWANN, 52, Old Broad Street, London.

Mr. DANIEL ADAMSON, Newton Moor Iron Works, Hyde Junction,
near Manchester.

STUDENT—

Mr. W. A. ROWELL, 1, Jesmond Gardens, Newcastle-upon-Tyne.

The following gentlemen were nominated for election at the next meeting :—

MEMBERS—

Mr. JOSEPH ROUTLEDGE, Viewer, Ryhope Colliery, Sunderland.

Mr. JOHN F. LLOYD, M.E., Saltburn-by-the-Sea.

Mr. THOMAS NUTTALL, M.E., Broad Street, Bury, Lancashire.

Mr. A. J. BARRAT, Ruabon Coal Company, Ruabon.

Mr. THOMAS W. BOURNE, 18, Hereford Square, London, S.W.

Mr. WILLIAM RAMSAY, Tursdale Colliery, County of Durham.

Mr. JAMES FLETCHER, Manager, Co-operative Collieries, Wallsend,
near Newcastle, New South Wales.

Mr. MAURICE DEACON, M.E., Bath Colliery, Somersetshire.

Mr. WILLIAM BESWICKE, M.E., Waithland House, Rochdale.

Mr. SIMON TATE, Kimblesworth Colliery, County Durham.

STUDENTS—

Mr. WILLIAM PICKSTONE, Oak Bank, Black Lane, near Manchester.

Mr. JAMES HOLME, Crewe Coal and Iron Co. Limited, Madeley
Collieries, near Newcastle-under-Lyme, Staffordshire.

Mr. THOMAS O. ROBSON, Lofthouse Mines, Saltburn-by-the-Sea.

Mr. ROBERT CLARK, 22, Windsor Terrace, Newcastle-on-Tyne.

Mr. JOHN D. WILSON, 15, West Street, Gateshead.

The discussion on Mr. Bunning's paper "On the Present Form of Marine Engine used in the Commercial Navy of Great Britain," was then resumed :—

Mr. WILLIAM BOYD said, that he thought it would add very much to the interest of Mr. Bunning's paper, if that gentleman could still further illustrate the diagram C, represented in Plate XXVII., Figs. 1, 2, and 3, which gave the various torsional effects produced on the shaft of similar engines, with cranks at three different angles. If the areas of these figures could be represented by a circular line, it would show by its diameter at once if there was any development of power to be gained by the adoption of any particular angle of crank under similar circumstances of expansion. On page 120 there was a list of the data upon which the passing of a boiler by the Board of Trade Surveyor depended. These data assumed that, before the given factor of safety of "six" can be employed, the boilers are to be made of the best materials, with all the rivet holes drilled through both plates, while they are cottered up in their places, and all the seams fitted with double butt straps. He thought that the desirability or not of enforcing some of these conditions was open to considerable question. For instance, he thought drilling the rivet holes through the plates when cottered up was not necessary. He understood that the holes were "drilled" to insure that they should be perfectly fair one with the other; and it was certainly true that the old fashioned way of punching holes—where the plates were marked off from a template, and carried by a number of men to the punching machine which was running tolerably fast, and were pushed along so that the punch came as closely down upon the mark as possible—could scarcely be considered satisfactory; but with self-acting dividing punching machines, such as were now in use, the distance from hole to hole was determined with mathematical accuracy, and the tables of these machines could, by a very simple adjustment, be made to vary the distance between hole and hole to suit the inside and outside plates of curved surfaces. It, therefore, became possible to punch holes that should be as accurately true one with the other when the plates were put together, as they would have been had they been drilled. Again, he thought that drilling the rivet holes allowed the employment of inferior iron. Boiler plates are now used so thick that it required a very excellent quality of plate to stand being punched without cracking, whereas, of course, a hole could be drilled in any quality of plate. Then again, a drilled hole put through both plates together was perfectly parallel, and had no taper or counter sink in it whatever; now, the heads of rivets in marine boilers are very much subject to corrosion, and when these heads are eaten away the rivet itself has no hold whatever if the holes are parallel, whereas, if the holes are punched and the plates are properly put together, there would be a counter sink on each side in opposite directions, which counter-

sink would to some extent hold the plates together even after the heads of the rivets were eaten away. Under these circumstances, he ventured to express his opinion that the principles laid down by the Board of Trade, and which he knew were adopted by many eminent engineers, were not in all cases sound.

Mr. LAWRENCE thought that Mr. Boyd had lost sight of the fact that although holes could be divided and punched accurately, even to suit the outside and inside plates of a curve, the thick plates now used must be very severely strained even when made of the best iron. With regard to Mr. Boyd's remark that drilling offered an inducement to manufacturers using an indifferent plate, he thought that those who did so would very soon lose their reputation if they ever had any, and that practically, parties ordering boilers only entrusted their construction to firms in whom they had confidence so far as to be sure that no inferior plate would be used. For his part, he thought the Board of Trade was quite right in allowing a less thickness of plate for a given pressure where drilled holes were used; and he thought the three grades set out by the Board of Trade—first, for punched holes; secondly, for holes drilled through the plates singly; and thirdly, for drilling both holes through both plates after they were fitted to their places and bolted together—were based on a sound appreciation of the necessities of the case. He noticed that there had been a very great improvement of late in drilling-machines for this purpose. The holes were made to converge towards the centre of the circle to which the plates were bent, and every pains was taken to obtain perfect mathematical accuracy, and he was sure that boilers so made must be better than those in which the holes were punched. He did not agree with Mr. Boyd that the taper holes produced by punching were better than parallel holes, for when the rivet heads had corroded he thought it was time the boiler should be repaired, and if the rivet fell out it would be all the better because it would insure that repair being done at once. He did not think that after the head had fallen off the irregularity or taper of the hole produced by punching would materially assist in keeping the plates together. He noticed that Mr. Bunning advocated the application of compound engines for the purposes of winding at collieries on account of the very much greater power they would develop in starting, but he could not exactly follow Mr. Bunning as to the way in which the extra power was obtained. In fact, this want of high initial power to make the lift had always seemed to him a difficulty attending the introduction of compound engines to the purpose proposed, for at the commencement no pressure could be got out

of the large cylinder until a stroke had been made by the high-pressure cylinder and the steam had passed through it to the large cylinder. And he thought there would be another difficulty attending the introduction of compound engines, for if they were applicable anywhere it would certainly be to deep pits, and these pits, in this district at all events, had very little water to spare for a condenser, without which the compound engine would have very little, if any, advantage over the single cylinder engine.

Mr. BUNNING stated that he would be very happy to illustrate the diagram referred to by Mr. Boyd in the way proposed if he had in his possession sufficient data to do so accurately. With regard to Mr. Lawrence's remark on the difficulty of starting the compound engine, he had expressly stated in his paper that he proposed not only to remove that difficulty but to give the compound engine an even greater initiative force than that of an ordinary engine, by introducing steam direct for the first stroke or so into the high pressure cylinder. With regard to the difficulty of obtaining water, it should be considered that the reason a compound engine is so economical is on account of the small amount of water in the form of steam which it uses to develop a given power, and this, of course, requires a proportionately small amount of water to condense, and renders the compound engine peculiarly suited to pit work where water is not abundant. He should very much like to have the opinion of their President on the much vexed question of drilled as against punched holes. That gentleman had had great experience, and had no doubt made many experiments on which he had founded that experience. In conclusion, he would remind the meeting that the formulæ given in the Table were drawn up from suggestions of, and were not general rules adopted by, the Board of Trade, and were chiefly useful as embodying the views of the surveyors; they did not free the maker from responsibility even if they had been complied with in every respect, should circumstances, in the opinion of the surveyor, render the boiler unfit to stand the pressure proposed.

Mr. LAWRENCE said he did not think Mr. Bunning's proposition of putting high pressure steam direct into the large cylinder was either a satisfactory or safe mode of overcoming the difficulty of commencing the lift. He thought it would be a very dangerous thing to give the engine-man power to put high pressure steam into the large cylinder whenever he chose, but still the difficulty might be got over by perhaps increasing the size of the high pressure cylinder, or by some arrangement of expansion gear. Again, if steam were admitted direct into the large

cylinder, the engine would cease to be a compound one, and as each lift often required but a few revolutions of the engine, the high pressure steam would be used in the large cylinder during an important percentage of the lift, and therefore much of the advantage of the compound arrangement would be destroyed, and much more water would be required to condense the great additional amount of steam employed.

Mr. WILLIAM BOYD did not see that allowing high pressure steam to pass direct into the low pressure cylinder for a stroke or so, would prevent the engine from realizing all the advantages of a compound engine during the sixteen or twenty strokes required to finish the lift. Neither did he think that any danger or inconvenience would accrue by giving the colliery enginemmen the means of admitting at will, high pressure steam into the low pressure cylinder.

Mr. BUNNING said, that at present the engines on board ships were always provided with means to allow the engineer, at will, to put high pressure steam into the low pressure cylinder, and this arrangement was found to produce no inconvenience whatever, but, on the contrary, made the engines much more easily handled when first put in motion.

Mr. LAWRENCE thought that no comparison whatever could be made between marine and colliery engines. The one worked continually when once set in motion, while the other had to be stopped for each lift, the duration of which rarely exceeded a minute, and all this would require an amount of complication, especially if the enginemman had to interfere with the usual gear of the engine by occasionally applying high pressure steam to the low pressure cylinder, that would render its use for winding purposes in that form unadvisable.

Mr. JOHN DAGLISH said, that the question of using expansion in winding engines was one of the greatest possible interest to the district generally. Up to the present time, to the best of his belief, expansion had not been used in winding engines anywhere in England until quite lately at Silksworth Colliery, but there are several appliances for using steam expansively on the Continent, and he had recently visited France and Belgium for the purpose of examining these engines. One of the difficulties of applying expansion to winding engines, was the necessity of having the expansion gear entirely and at all times under the control of the enginemman, so that he could at any time, when the gearing of the engine had closed the valves, have the power of immediately introducing steam and obtaining control of the engine, and more particularly should he have this power when the tubs were being changed, and when the engine was making the first strokes of its lift. This, with the necessity

that the engine must make so many strokes in one direction, and then so many in the opposite, at frequent intervals, seems to require complication of gear. At Silksworth, however, the expansion is regularly carried out, the engine is perfectly under control, with an amount of gear little more complicated than that usually employed—at this engine, during the whole time the tubs are being changed, the engineman could, by a motion of the link, give the engine full steam at any portion of the stroke; when winding, the first two revolutions were made with steam acting during the whole of the stroke, the engine then commenced cutting off at one-third of its stroke, and continued to do so until the end. The principle in operation at St. Etienne, in France, was that of M. Audemar, who employs a valve outside the valve chest, which, by a very simple appliance, was worked by a cam. There is also another much more complicated but very admirable appliance of M. Guinotte, son-in-law of Professor Guibal, whose name they knew so well in connection with the ventilating fan. In this arrangement, increased expansion was made to counterbalance the weight of the rope, the steam being cut off gradually, more and more from the commencement to the end of the lift, so as to balance the decreased weight of the rope as the load was lifted. Personally, he did not think this principle an entire success, and probably they would have, ere long, a paper before them in which this question would be raised, for, he believed, there was at present an engine being erected in the Midland Counties with this appliance. He believed that with a compound engine, the parts necessary for working expansively would be very much less complicated than with an ordinary engine; but otherwise, he did not see any advantage a compound engine had over a single engine constructed like the one at Silksworth.

Mr. A. L. STEAVENSON thought economy was hardly the first thing to be considered in a winding engine: at all events it should never interfere with simplicity and strength. At one time, in the collieries he was connected with, they were using a ton of coal to raise 12 tons; but now, by the application of heat from the coke ovens, they were drawing 160 tons of coal for every ton used under the boiler by the simple application of heat which otherwise would have been wasted from the coke ovens.

The PRESIDENT said, that not having read the paper or attended its first discussion, he felt unable to take any part in the present conversation. With regard to the particular question as to the comparative efficiency of punched and drilled holes, he might observe that it had for many years occupied the attention of the Elswick firm, and the general opinion was that where the punching and the rivetting were thoroughly well done, the

work produced was stronger when the holes were punched than when they were drilled. But there was more liability to want of coincidence of the holes in punching than there was in drilling, for of course the holes must be fair one with another. There was, therefore, on the whole, a better chance of making good work when the holes were drilled, although there was greater holding power when the holes were punched.

The scrutineers having returned, the SECRETARY read the names of the officers elected for the ensuing year, and the meeting terminated.

APPENDIX No. I.

BAROMETER AND THERMOMETER READINGS FOR 1874.

BY THE SECRETARY.

THESE readings have been obtained from the observatories of Kew and Glasgow, and will give a very fair idea of the variations of temperature and atmospheric pressure in the intervening country, in which most of the mining operations in this country are carried on.

The Kew barometer is 34 feet, and the Glasgow barometer 180 feet above the sea level. The latter readings have been reduced to 32 feet above the sea level, by the addition of $\cdot 150$ of an inch to each reading, and both readings are reduced to 32° Fahrenheit.

The fatal accidents have been obtained from the Inspectors' reports, and are printed across the lines, showing the various readings. The name of the colliery at which the explosion took place is given first, then the number of deaths, followed by the district in which it happened.

At the request of the Council the exact readings at both Kew and Glasgow have been published in figures.

BAROMETER READINGS, &c.

JANUARY, 1874.

KEW.							GLASGOW.						
BAROMETER.					TEM- PERATURE.		BAROMETER.					TEM- PERATURE.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maxi- mum.	Mini- mum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maxi- mum.	Mini- mum.
1	30.010	30.170	30.167	30.095	46.0	34.4	1	29.751	29.813	29.618	29.294	46.8	44.1
2	29.910	29.877	29.894	29.894	50.5	38.4	2	29.370	29.300	29.384	29.378	50.6	35.2
3	29.700	29.378	29.359	29.486	48.1	41.8	3	29.388	29.242	29.161	29.161	38.9	31.7
4	29.425	29.542	29.610	29.736	41.5	34.1	4	29.195	29.301	29.319	29.471	42.7	31.4
5	29.805	29.984	30.104	30.227	39.7	33.8	5	29.705	29.841	29.807	29.835	42.7	31.1
6	30.275	30.346	30.361	30.353	42.7	29.0	6	29.869	29.919	29.946	30.006	47.3	41.2
7	30.300	30.232	30.117	30.049	43.3	32.6	7	29.966	29.862	29.690	29.620	47.7	41.3
8	29.930	29.866	29.760	29.772	44.4	32.6	8	29.554	29.468	29.344	29.272	46.5	39.0
9	29.715	29.798	29.869	29.979	48.9	38.8	9	29.352	29.548	29.671	29.793	48.1	38.2
10	30.005	30.061	30.028	30.080	51.5	42.4	10	29.859	29.943	29.984	29.988	46.5	34.1
11	30.100	30.129	30.010	29.996	37.9	33.2	11	29.848	29.742	29.550	29.510	47.6	34.9
12	29.900	29.882	29.884	30.003	49.2	34.0	12	29.514	29.604	29.664	29.730	48.3	35.1
13	30.050	30.140	30.066	30.017	43.7	29.7	13	29.822	29.794	29.624	29.614	47.3	35.1
14	29.970	29.982	29.965	30.001	50.4	34.0	14	29.546	29.622	29.654	29.654	48.3	41.3
15	29.950	29.913	29.882	29.782	49.7	45.8	15	29.466	29.412	29.371	29.277	48.9	42.2
16	29.635	29.492	29.276	29.423	49.7	45.0	16	29.155	29.117	29.076	29.088	48.0	32.2
17	29.455	29.549	29.693	29.832	41.5	35.3	17	29.132	29.316	29.502	29.550	36.7	31.3
18	29.835	29.720	29.590	29.599	51.8	30.4	18	29.364	29.094	28.840	29.032	51.9	32.0
19	29.660	29.657	29.652	29.676	47.2	42.2	19	29.106	29.320	29.479	29.515	43.5	35.0
20	29.650	29.674	29.698	29.823	54.4	43.5	20	29.219	29.085	29.125	29.429	46.5	32.1
21	29.980	30.139	30.212	30.355	50.3	39.6	21	29.595	29.751	29.917	30.055	48.2	38.0
22	29.385	30.436	30.357	30.362	41.0	30.5	22	30.113	30.131	30.080	30.036	48.3	42.2
23	30.250	30.250	30.206	30.190	48.8	32.0	23	29.904	29.896	29.914	29.930	46.7	38.1
24	30.130	30.123	30.231	30.380	43.7	43.0	24	29.918	29.998	30.117	30.279	42.2	32.8
25	30.470	30.526	30.500	30.538	43.4	30.6	25	30.249	30.233	30.191	30.155	44.8	30.9
26	30.475	30.434	30.372	30.377	47.5	33.3	26	30.045	30.003	30.025	30.161	50.2	43.3
27	30.370	30.475	30.467	30.521	49.3	42.0	27	30.279	30.399	30.396	30.434	47.2	40.8
28	30.525	30.540	30.505	30.496	46.7	37.2	28	30.448	30.434	30.386	30.344	48.3	42.3
29	30.430	30.400	30.314	30.292	43.5	42.2	29	30.248	30.142	30.015	30.067	45.5	41.1
30	30.300	30.430	30.446	30.506	46.6	41.3	30	30.161	30.259	30.322	30.342	44.2	44.8
31	30.500	30.516	30.467	30.486	48.6	32.7	31	30.356	30.354	30.348	30.382	46.9	41.8

FEBRUARY, 1874.

1	30.460	30.488	30.465	30.472	46.9	36.7	1	30.368	30.364	30.324	30.296	44.5	40.2
2	30.425	30.419	30.367	30.365	43.5	39.9	2	30.224	30.170	30.125	30.049	46.2	40.2
3	30.340	30.399	30.421	30.515	45.4	37.7	3	30.229	30.385	30.423	30.489	45.2	40.2
4	30.565	30.617	30.599	30.620	42.6	32.9	4	30.195	30.523	30.493	30.483	43.5	39.7
5	30.600	30.614	30.543	30.535	33.6	26.0	5	30.463	30.439	30.424	30.418	42.7	37.8
6	30.475	30.493	30.424	30.413	30.5	25.2	6	30.384	30.366	30.287	30.260	41.5	32.0
7	30.350	30.322	30.226	30.109	44.8	25.7	7	30.197	30.139	29.986	29.926	47.5	32.0
8	30.040	30.117	30.150	30.291	43.3	28.9	8	30.072	30.224	30.258	30.308	47.2	31.1
9	30.260	30.297	30.250	30.276	36.7	26.1	9	30.268	30.268	30.265	30.333	39.7	26.0
10	30.325	30.518	30.573	30.603	33.7	29.2	10	30.383	30.451	30.446	30.418	36.9	29.2
11	30.510	30.434	30.281	30.197	36.3	22.4	11	30.322	30.206	30.102	30.052	39.2	23.8
12	30.065	30.062	30.017	29.996	46.3	26.0	12	29.946	29.906	29.847	29.811	35.7	28.3
13	30.000	30.004	29.918	29.902	48.0	35.2	13	29.713	29.559	29.400	29.414	47.5	36.5
14	29.825	29.738	29.608	29.516	51.3	46.1	14	29.279	29.208	29.156	29.150	50.3	42.7
15	29.410	29.433	29.390	29.462	51.9	46.9	15	29.106	29.108	29.106	29.154	47.2	38.2
16	29.470	29.452	29.518	29.527	48.3	44.7	16	29.234	29.320	29.268	29.164	48.2	37.2
17	29.350	29.228	29.341	29.450	46.0	41.4	17	29.010	29.082	29.152	29.244	43.4	35.0
18	29.500	29.575	29.652	29.794	44.9	31.2	18	29.334	29.480	29.596	29.736	42.8	30.5
19	29.860	29.996	30.062	30.162	45.9	33.5	19	29.808	29.934	29.981	30.043	46.3	29.8
20	30.170	30.231	30.179	30.185	16.0	26.4	20	30.013	29.959	29.876	29.836	43.7	31.3
21	30.090	30.039	29.951	29.912	46.9	28.4	21	29.730	29.684	29.683	29.729	42.3	41.4
22	29.825	29.796	29.715	29.762	46.3	40.8	22	29.733	29.753	29.724	29.736	42.8	36.1
23	29.780	29.864	29.912	29.980	43.7	40.9	23	29.758	29.798	29.798	29.824	44.8	31.4
24	30.000	30.043	30.007	29.994	44.9	39.1	24	29.824	29.860	29.847	29.825	44.3	39.9
25	29.900	29.833	29.685	29.582	44.3	33.0	25	29.749	29.631	29.458	29.212	45.2	36.2
26	29.390	29.265	29.122	29.074	48.0	38.4	26	29.098	28.802	28.785	28.771	46.3	35.5
27	28.950	29.266	29.451	29.702	51.9	41.6	27	28.787	28.847	28.985	29.371	49.4	39.3
28	29.865	29.978	29.952	29.933	53.1	31.1	28	29.641	29.789	29.751	29.683	48.7	34.5

BAROMETER READINGS, &c.

MARCH, 1874.

KEW.							GLASGOW.						
BAROMETER.						TEM- PERATURE.	BAROMETER.						TEM- PERATURE.
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maxi- mum.	Mini- mum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maxi- mum.	Mini- mum.
1	29.875	29.938	30.010	30.154	54.9	37.2	1	29.639	29.739	29.871	30.011	48.2	40.3
2	30.250	30.380	30.414	30.497	51.7	40.3	2	30.171	30.291	30.331	30.417	49.3	39.3
3	30.530	30.565	30.515	30.559	49.7	38.7	3	30.413	30.427	30.399	30.403	49.3	43.2
4	30.555	30.589	30.527	30.564	45.7	29.5	4	30.391	30.427	30.374	30.382	49.5	44.3
5	30.550	30.552	30.500	30.548	47.0	33.5	5	30.372	30.404	30.505	30.685	50.8	40.1
6	30.605	30.707	30.697	30.715	49.7	38.7	6	30.785	30.805	30.709	30.659	47.7	31.0
7	30.650	30.563	30.405	30.329	51.9	31.7	7	30.559	30.479	30.333	30.163	48.5	34.3
8	30.195	30.092	29.910	29.818	51.9	26.9	8	29.923	29.779	29.606	29.564	48.4	35.2
9	29.610	29.517	29.535	29.546	43.7	34.1	9	29.522	29.628	29.614	29.714	36.7	27.3
10	29.595	29.685	29.715	29.881	36.0	26.6	10	29.690	29.784	29.823	29.902	33.2	24.9
11	29.925	29.969	30.040	30.174	35.6	22.9	11	29.956	30.046	30.179	30.115	37.8	23.0
12	30.215	30.196	30.097	30.169	43.7	25.5	12	30.049	30.061	30.010	30.130	47.3	30.8
13	30.250	30.362	30.372	30.447	46.3	31.4	13	30.160	30.218	30.273	30.335	48.2	36.4
14	30.445	30.480	30.412	30.377	51.5	39.9	14	30.257	30.225	30.153	30.141	47.0	42.2
15	30.315	30.319	30.300	30.331	53.6	42.3	15	30.117	30.117	30.099	30.077	48.4	45.2
16	30.319	30.308	30.261	30.259	53.4	40.5	16	30.017	29.977	29.948	29.902	48.4	41.9
17	30.230	30.234	30.207	30.197	55.2	45.1	17	29.846	29.810	29.946	29.782	53.4	46.2
18	30.060	30.041	30.048	30.144	57.9	46.8	18	29.720	29.818	29.923	30.009	49.9	39.2
19	30.140	30.038	29.794	29.845	52.6	35.7	19	29.875	29.415	29.444	29.502	49.3	35.0
20	29.920	30.001	30.046	30.148	49.9	38.2	20	29.708	29.864	29.935	30.047	48.4	37.3
21	30.168	30.149	30.068	30.067	53.7	38.0	21	29.835	29.767	29.651	29.587	50.3	40.2
22	30.044	30.069	30.105	30.199	57.9	44.7	22	29.591	29.769	29.875	29.987	52.3	46.8
23	30.240	30.277	30.215	30.270	64.7	47.4	23	30.031	30.087	30.081	30.063	54.5	46.1
24	30.250	30.307	30.288	30.411	57.7	41.9	24	30.007	30.159	30.292	30.392	53.2	39.5
25	30.410	30.425	30.333	30.367	53.9	36.8	25	30.410	30.400	30.296	30.269	57.8	36.4
26	30.345	30.373	30.294	30.249	54.0	30.3	26	30.206	30.150	30.102	29.976	51.8	37.4
27	30.122	30.045	29.929	29.961	61.0	31.3	27	29.794	29.682	29.498	29.454	50.1	42.3
28	30.031	30.125	30.031	29.960	56.7	41.8	28	29.728	29.666	29.462	29.482	47.2	40.3
29	29.830	29.856	29.825	29.793	57.9	48.8	29	29.394	29.278	29.260	29.284	53.7	41.1
30	Recddict	29.921	29.945	30.004	55.0	46.1	30	29.294	29.390	29.613	29.593	49.2	39.7
31	29.860	29.833	29.835	30.021	55.7	48.2	31	29.373	29.427	29.467	29.557	50.3	37.9

APRIL, 1874.

1	30.025	30.053	30.019	29.937	56.0	38.8	1	29.507	29.655	29.679	29.283	47.3	34.7
2	29.715	29.654	29.460	29.237	56.3	47.0	2	29.161	29.075	28.736	28.570	50.7	42.2
3	29.145	29.314	29.381	29.380	52.8	47.9	3	28.460	28.856	29.028	29.144	49.2	35.0
4	29.475	29.475	29.481	29.440	47.0	38.6	4	28.964	29.032	29.051	29.095	45.8	34.3
5	29.410	29.505	29.530	29.607	53.8	40.2	5	29.105	29.169	29.255	29.355	47.4	37.3
6	29.650	29.751	29.830	29.967	54.9	34.0	6	29.441	29.591	29.709	29.841	46.8	38.6
7	30.010	30.017	29.924	29.893	56.3	36.3	7	29.863	29.805	29.684	29.598	47.7	35.8
8	29.800	29.898	29.911	29.934	55.7	43.6	8	29.630	29.640	29.633	29.539	47.5	36.3
9	29.835	29.690	29.528	29.411	51.0	38.7	9	29.319	29.301	29.294	29.272	52.5	41.3
10	29.360	29.361	29.326	29.345	53.9	43.8	10	29.186	29.200	29.171	29.173	51.6	38.6
11	29.275	29.208	29.187	29.296	55.3	33.1	11	29.119	29.169	29.222	29.334	50.7	37.4
12	29.345	29.491	29.605	29.674	49.6	42.3	12	29.400	29.520	29.558	29.542	52.4	34.0
13	29.600	29.345	29.156	29.226	51.5	36.1	13	29.282	29.122	29.196	29.512	42.4	35.1
14	29.465	29.716	29.837	29.980	53.0	40.4	14	29.758	29.950	30.029	30.099	58.3	39.8
15	30.005	30.055	30.066	30.026	53.5	42.9	15	30.071	30.037	29.960	29.974	48.7	37.0
16	29.955	29.972	29.901	29.946	58.8	42.6	16	29.904	29.810	29.685	29.783	50.0	38.4
17	29.950	30.004	30.066	30.041	56.7	42.7	17	29.761	29.811	29.852	29.894	48.9	36.6
18	29.995	29.991	30.024	30.085	62.4	48.2	18	29.876	29.900	29.875	29.873	49.8	39.2
19	30.075	30.107	30.070	30.101	62.4	46.6	19	29.887	29.909	29.893	29.867	56.7	47.9
20	30.090	30.087	30.002	30.022	66.8	44.1	20	29.867	29.895	29.848	29.836	55.7	48.4
21	30.000	29.966	29.907	29.970	74.9	39.7	21	29.814	29.774	29.713	29.733	63.8	49.8
22	30.026	30.079	30.060	30.147	67.3	45.0	22	29.883	30.027	30.083	30.069	56.8	44.8
23	30.113	30.101	30.052	30.101	76.3	46.1	23	30.069	30.015	29.954	29.934	63.4	37.2
24	30.120	30.148	30.127	30.165	74.7	49.7	24	29.954	29.984	29.980	30.012	57.9	49.9
25	30.145	30.150	30.098	30.116	67.3	52.6	25	30.026	30.060	30.050	30.082	64.7	50.3
26	30.140	30.145	30.125	30.181	72.3	49.6	26	30.076	30.102	30.086	30.122	67.6	52.3
27	30.175	30.178	30.123	30.187	75.3	49.1	27	30.162	30.180	30.157	30.223	57.1	46.2
28	30.290	30.249	30.250	30.322	61.9	49.5	28	30.229	30.261	30.230	30.298	57.2	43.3
29	30.300	30.297	30.216	30.175	57.6	38.7	29	30.296	30.262	30.160	30.104	60.9	40.5
30	30.060	29.999	29.881	29.913	67.0	33.1	30	30.024	29.968	29.902	29.973	68.7	39.0

BAROMETER READINGS, &c.

MAY, 1874.

KEW.							GLASGOW.						
Date.	BAROMETER.				TEM- PERATURE.		Date.	BAROMETER.				TEM- PERATURE.	
	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maxi- mum.	Mini- mum.		4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maxi- mum.	Mini- mum.
1	29.930	29.989	29.991	30.084	55.9	46.7	1	30.011	30.057	30.084	30.148	53.6	42.2
2	30.075	30.076	30.037	30.014	53.1	35.0	2	30.172	30.162	30.085	30.045	54.7	34.5
3	29.910	29.836	29.750	29.772	52.1	35.4	3	29.923	29.817	29.822	29.876	54.1	40.3
4	29.780	29.818	29.853	29.894	50.3	35.8	4	29.800	29.924	29.930	29.984	48.8	38.8
5	29.880	29.912	29.913	29.918	50.9	30.8	5	29.984	29.974	29.915	29.859	52.7	36.2
6	29.875	29.828	29.774	29.748	54.9	41.8	6	29.761	29.755	29.692	29.684	49.3	40.2
7	29.696	29.690	29.646	29.663	55.5	38.5	7	29.668	29.664	29.658	29.706	50.0	34.9
8	29.626	29.616	29.605	29.621	52.3	38.7	8	29.692	29.692	29.654	29.672	50.9	36.8
9	29.616	29.649	29.684	29.772	50.5	34.0	9	29.666	29.684	29.697	29.783	50.0	34.5
10	29.815	29.876	29.900	29.972	51.8	32.6	10	29.833	29.883	29.885	29.959	54.9	38.2
11	30.020	30.088	30.088	30.124	53.9	32.4	11	30.013	30.081	30.105	30.175	53.8	40.0
12	30.150	30.152	30.141	30.187	43.8	35.7	12	30.211	30.247	30.271	30.315	46.9	37.2
13	30.235	30.318	30.323	30.342	58.9	44.1	13	30.317	30.329	30.296	30.314	47.7	39.7
14	30.310	30.326	30.295	30.238	56.7	46.6	14	30.292	30.266	30.192	30.066	52.0	36.0
15	30.075	30.019	30.197	30.319	53.5	48.5	15	30.136	30.274	30.295	30.351	53.7	38.0
16	30.350	30.356	30.315	30.317	56.7	35.8	16	30.353	30.337	30.265	30.383	60.6	37.6
17	30.325	30.310	30.235	30.243	58.7	36.4	17	30.287	30.279	30.227	30.231	63.3	35.1
18	30.250	30.254	30.213	30.218	59.5	34.3	18	30.223	30.223	30.208	30.270	65.8	39.3
19	30.245	30.239	30.199	30.223	57.3	40.0	19	30.280	30.290	30.274	30.292	56.5	44.2
20	30.218	30.202	30.144	30.135	59.3	38.7	20	30.296	30.268	30.182	30.160	53.3	40.8
21	30.054	29.952	29.837	29.776	63.0	41.9	21	30.104	30.062	29.964	29.912	51.7	42.2
22	29.650	29.592	29.533	29.527	71.9	49.4	22	29.816	29.782	29.706	29.694	52.0	44.2
23	29.488	29.476	29.444	29.465	62.3	51.3	23	29.628	29.618	29.567	29.607	53.3	43.3
24	29.480	29.533	29.555	29.641	70.4	53.3	24	29.581	29.607	29.619	29.683	49.6	46.4
25	29.700	29.753	29.800	29.872	72.3	50.3	25	29.735	29.809	29.867	29.919	50.8	46.3
26	29.91	29.933	29.911	29.995	66.7	48.4	26	29.931	29.955	29.934	29.932	54.3	46.1
27	29.991	30.012	29.961	29.989	72.3	46.9	27	29.932	29.924	29.823	29.597	58.2	45.2
28	29.995	30.006	29.990	30.009	68.5	53.1	28	29.603	29.939	29.788	29.835	57.6	48.4
29	29.900	29.994	29.938	29.915	66.3	55.3	29	29.814	29.806	29.720	29.584	57.5	41.1
30	29.850	29.864	29.849	29.936	70.7	51.9	30	29.474	29.538	29.545	29.613	59.2	50.0
31	29.985	30.019	30.000	30.086	71.7	49.6	31	29.623	29.649	29.607	29.641	60.8	52.2

JUNE, 1874.

1	30.101	30.134	30.111	30.091	71.5	52.7	1	29.733	29.827	29.810	29.814	58.7	50.8
2	30.035	29.963	29.924	29.969	78.3	52.1	2	29.766	29.796	29.798	29.850	61.7	54.2
3	30.053	30.138	30.224	30.345	71.7	54.3	3	29.938	30.054	30.145	30.219	65.8	47.2
4	30.405	30.445	30.382	30.390	77.3	49.4	4	30.225	30.231	30.211	30.235	66.2	49.8
5	30.345	30.290	30.177	30.159	78.3	48.3	5	30.239	30.237	30.178	30.126	61.5	49.9
6	30.089	30.073	30.041	30.106	74.0	59.2	6	30.032	30.048	30.072	30.118	57.4	44.2
7	30.106	30.168	30.144	30.212	67.0	52.8	7	30.118	30.142	30.122	30.118	59.7	42.8
8	30.224	30.242	30.169	30.189	71.6	44.9	8	30.184	30.094	30.104	30.104	60.7	51.5
9	30.149	30.137	30.070	30.095	78.9	46.1	9	30.054	29.992	29.877	29.859	58.3	48.4
10	30.096	30.130	30.158	30.270	69.3	54.3	10	29.917	30.017	30.087	30.093	54.6	45.1
11	30.276	30.191	30.066	30.124	73.3	44.1	11	29.925	29.777	30.015	30.241	60.8	47.2
12	30.258	30.341	30.340	30.388	60.0	45.9	12	30.333	30.339	30.360	30.406	60.3	38.0
13	30.369	30.376	30.345	30.363	59.0	38.9	13	30.430	30.442	30.377	30.395	65.3	40.2
14	30.343	30.362	30.379	30.478	60.8	41.3	14	30.437	30.497	30.479	30.563	66.2	44.4
15	30.501	30.503	30.427	30.421	63.9	43.9	15	30.595	30.591	.....	30.584	69.4	47.3
16	30.321	30.251	30.191	30.140	61.7	48.7	16	30.520	30.482	30.394	30.372	67.6	49.2
17	30.086	30.061	30.114	30.201	64.8	49.3	17	30.358	30.324	30.277	30.359	73.4	45.9
18	30.219	30.262	30.253	30.283	57.3	51.1	18	30.339	30.315	30.243	30.267	71.4	48.0
19	30.272	30.275	30.182	30.163	64.8	48.6	19	30.233	30.197	30.159	30.201	69.5	47.1
20	30.150	30.158	30.138	30.133	57.7	48.1	20	30.205	30.179	30.090	30.036	64.3	46.9
21	30.067	30.024	29.940	29.927	65.7	43.4	21	29.966	29.914	29.862	29.858	63.4	51.1
22	29.915	29.935	29.934	29.992	75.3	41.1	22	29.836	29.870	29.856	29.870	68.7	47.0
23	29.991	29.980	29.931	29.898	69.8	49.7	23	29.808	29.742	29.667	29.675	63.3	48.7
24	29.826	29.815	29.816	29.829	64.3	53.1	24	29.635	29.645	29.604	29.648	66.2	50.1
25	29.787	29.797	29.786	29.762	66.8	52.2	25	29.658	29.662	29.639	29.637	57.3	46.1
26	29.653	29.619	29.593	29.597	60.0	53.0	26	29.611	29.625	29.600	29.636	66.2	43.3
27	29.591	29.619	29.578	29.621	68.7	53.7	27	29.648	29.620	29.578	29.616	68.8	47.0
28	29.631	29.692	29.748	29.859	62.9	52.4	28	29.652	29.708	29.726	29.774	68.6	45.0
29	29.904	29.923	29.875	29.855	64.8	51.1	29	29.798	29.806	29.772	29.804	68.9	48.4
30	29.903	29.989	29.962	29.982	73.3	56.7	30	29.796	29.760	29.622	29.600	60.8	45.7

BAROMETER READINGS, &c.

JULY, 1874.

KEW.							GLASGOW.						
BAROMETER.					TEM- PERATURE.		BAROMETER.					TEM- PERATURE.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maxi- mum.	Mini- mum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maxi- mum.	Mini- mum.
1	29.970	30.016	30.001	30.006	68.8	59.5	1	29.666	29.714	29.702	29.662	66.8	55.4
2	29.967	29.843	29.818	29.889	81.7	52.7	2	29.634	29.588	29.513	29.516	68.8	56.2
3	29.929	29.987	29.997	30.021	70.7	58.5	3	29.517	29.527	29.540	29.564	66.3	53.8
4	30.027	30.045	30.040	30.118	68.3	56.1	4	29.576	29.596	29.640	29.728	58.7	53.0
5	30.154	30.186	30.180	30.249	70.8	51.1	5	29.808	29.940	30.042	30.054	59.9	49.9
6	30.261	30.263	30.194	30.191	70.8	48.6	6	30.154	30.170	30.142	30.120	58.9	48.3
7	30.146	30.129	30.052	30.047	75.8	49.3	7	30.072	30.050	29.980	29.950	63.8	51.8
8	30.044	30.063	30.053	30.102	81.9	49.6	8	29.902	29.934	29.957	29.993	68.8	53.2
9	30.101	30.105	30.058	30.083	87.6	53.4	9	29.969	29.993	30.050	30.108	67.3	56.2
10	30.076	30.095	30.004	30.035	85.7	63.6	10	30.120	30.126	30.077	30.081	65.8	49.1
11	29.989	29.975	29.915	29.950	78.0	64.8	11	30.049	30.035	29.998	30.006	63.4	46.2
12	29.953	29.997	29.995	30.034	79.1	60.0	12	29.992	30.016	29.998	30.002	66.3	57.4
13	30.060	30.105	30.067	30.066	78.3	59.1	13	30.012	30.008	29.970	29.930	65.8	48.3
14	30.046	30.023	29.982	30.005	82.8	58.6	14	29.834	29.858	29.903	29.959	69.1	57.9
15	30.053	30.102	30.000	30.153	79.3	58.1	15	30.009	30.087	30.103	30.137	68.6	54.8
16	30.173	30.180	30.157	30.211	75.3	55.6	16	30.183	30.181	30.132	30.124	68.9	51.9
17	30.209	30.236	30.198	30.243	76.5	52.1	17	30.108	30.114	30.131	30.153	76.3	63.8
18	30.237	30.231	30.145	30.158	76.8	50.4	18	30.161	30.173	30.117	30.105	79.8	56.4
19	30.107	30.078	29.955	29.970	87.3	53.8	19	30.049	30.007	29.947	29.931	79.5	58.8
20	29.913	29.873	29.772	29.808	85.7	56.1	20	29.885	29.853	29.775	29.755	68.9	56.9
21	29.788	29.753	29.745	29.852	74.8	58.1	21	29.655	29.613	29.600	29.626	64.5	55.1
22	29.878	29.904	29.877	29.870	69.9	53.1	22	29.650	29.694	29.682	29.696	64.8	53.7
23	29.824	29.817	29.770	29.822	74.7	57.5	23	29.660	29.674	29.654	29.666	66.9	52.7
24	29.816	29.778	29.782	29.824	68.3	51.1	24	29.682	29.762	29.784	29.834	68.5	50.1
25	29.872	29.908	29.857	29.849	75.8	47.7	25	29.832	29.828	29.754	29.670	67.3	46.1
26	29.780	29.678	29.658	29.708	73.3	55.6	26	29.546	29.510	29.452	29.462	66.8	54.5
27	29.711	29.736	29.678	29.687	69.7	56.4	27	29.480	29.542	29.547	29.579	67.3	51.7
28	29.642	29.623	29.601	29.622	67.5	53.3	28	29.545	29.551	29.542	29.588	63.5	48.1
29	29.639	29.679	29.725	29.805	71.3	49.1	29	29.610	29.640	29.660	29.696	69.2	49.2
30	29.883	29.926	29.937	30.018	74.8	52.1	30	29.714	29.770	29.798	29.836	63.4	52.2
31	30.042	30.026	29.999	29.949	71.5	52.2	31	29.826	29.768	29.624	29.616	59.7	53.8

AUGUST, 1874.

1	29-893	29-905	29-897	29-916	69.4	60.1	1	29-672	29-722	29-754	29-740	63.8	51.2
2	29-844	29-787	29-720	29-763	76.3	60.1	2	29-452	.....	.....	.....	61.2	54.0
3	29-811	29-892	29-928	30-023	69.5	52.1	3	.....	29-760	.....	.....	61.5	48.2
4	29-990	29-902	29-710	29-756	64.5	50.7	4	29-743	29-699	29-692	29-748	60.7	48.4
5	29-815	29-801	29-626	29-589	62.9	49.8	5	29-662	29-490	29-674	29-410	58.8	46.5
6	29-689	29-842	29-875	29-927	71.6	55.0	6	29-558	29-690	29-774	29-700	60.8	49.2
7	29-860	29-804	29-751	29-699	71.7	53.9	7	29-380	29-348	29-386	29-396	66.2	50.1
8	29-618	29-618	29-651	29-745	67.5	55.0	8	29-380	29-382	29-399	29-399	63.3	51.3
9	29-770	29-826	29-780	29-608	66.0	52.8	9	29-553	29-579	29-548	29-462	62.8	49.8
10	29-548	29-558	29-523	29-536	67.8	55.9	10	29-336	29-308	29-288	29-316	61.8	49.4
11	29-650	29-690	29-708	29-753	65.9	51.5	11	29-330	29-354	29-371	29-381	59.2	45.5
12	29-701	29-736	29-740	29-678	64.8	48.9	12	29-369	29-381	29-446	29-458	57.3	50.5
13	29-621	29-562	29-461	29-433	66.6	56.4	13	29-418	29-390	29-307	29-365	61.7	44.5
14	29-373	29-450	29-582	29-774	64.9	54.6	14	29-207	29-309	29-431	29-567	60.5	49.3
15	29-883	29-984	30-015	30-058	67.7	51.1	15	29-655	29-645	29-637	29-739	61.7	48.5
16	30-050	30-064	30-073	30-063	66.6	53.7	16	29-761	29-771	29-747	29-791	60.8	50.5
17	30-092	30-155	30-163	30-216	68.3	50.8	17	29-851	29-945	30-021	30-051	58.7	50.1
18	30-254	30-290	30-239	30-309	72.3	48.9	18	29-961	29-987	30-008	30-186	63.8	50.2
19	30-336	30-364	30-309	30-352	76.8	59.5	19	30-206	30-236	30-236	30-290	69.8	53.0
20	30-347	30-373	30-315	30-380	78.8	57.9	20	30-320	30-364	30-385	30-453	65.7	55.0
21	30-404	30-456	30-411	30-468	73.3	56.1	21	30-453	30-467	30-428	30-426	68.6	53.2
22	30-445	30-428	30-355	30-346	72.8	47.9	22	30-392	30-380	30-319	30-321	73.3	48.1
23	30-312	30-307	30-265	30-328	77.3	45.0	23	30-319	30-343	30-295	30-301	67.8	52.2
24	30-394	30-287	30-176	30-131	71.6	46.7	24	30-243	30-215	30-123	30-099	60.8	50.0
25	30-057	30-041	29-998	30-077	74.8	56.5	25	30-051	30-069	30-055	30-065	63.2	53.2
26	30-055	30-061	29-978	29-946	71.9	47.2	26	29-979	29-959	29-866	29-778	62.4	54.8
27	29-864	29-818	29-750	29-741	70.2	47.2	27	29-640	29-572	29-427	29-607	60.6	49.1
28	29-766	29-842	29-805	29-869	70.8	51.7	28	29-651	29-675	29-649	29-611	62.2	45.2
29	29-808	29-797	29-735	29-844	65.0	50.5	29	29-525	29-491	29-523	29-583	59.8	47.4
30	29-871	29-893	29-840	29-781	69.3	49.3	30	29-603	29-627	29-553	29-409	59.2	40.4
31	29-694	29-800	29-822	29-805	70.8	58.9	31	29-361	29-427	29-495	29-521	62.3	52.0

BAROMETER READINGS, &c.

SEPTEMBER, 1874.

KEW.							GLASGOW.						
Date.	BAROMETER.				TEM- PERATURE.		Date.	BAROMETER.				TEM- PERATURE.	
	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maxi- mum.	Mini- mum.		4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maxi- mum.	Mini- mum.
1	29.717	29.673	29.724	29.785	73.2	62.0	1	29.373	29.195	29.385	29.479	63.4	52.0
2	29.796	29.873	29.905	29.966	70.8	54.1	2	29.443	29.439	29.506	29.578	63.0	38.5
3	29.933	29.879	29.715	29.540	65.9	54.1	3	29.578	29.580	29.556	29.556	59.7	49.2
4	29.709	29.893	29.885	29.933	62.3	52.9	4	29.506	29.548	29.617	29.753	59.3	49.2
5	29.946	30.006	29.973	29.994	64.8	47.1	5	29.793	29.787	29.781	29.835	66.0	47.4
6	29.950	29.983	29.915	29.955	58.7	51.3	6	29.831	29.865	29.874	29.900	59.5	44.0
7	29.967	30.013	29.962	29.962	65.8	43.7	7	29.861	29.844	29.806	29.788	58.5	49.0
8	29.950	29.966	29.872	29.810	66.8	56.9	8	29.776	29.770	29.672	29.504	57.7	47.0
9	29.646	29.492	29.474	29.496	63.3	55.1	9	29.332	29.292	29.310	29.176	60.5	42.0
10	29.497	29.601	29.658	29.728	63.1	45.9	10	29.092	29.078	29.148	29.326	54.5	46.0
11	29.756	29.682	29.528	29.458	64.8	50.6	11	29.388	29.350	29.270	29.254	60.5	47.9
12	29.523	29.640	29.730	29.921	65.0	55.1	12	29.430	29.612	29.737	29.917	61.0	41.4
13	30.012	30.156	30.210	30.304	64.4	45.7	13	30.029	30.125	30.178	30.204	57.0	42.7
14	30.334	30.353	30.309	30.281	65.0	49.1	14	30.160	30.066	29.918	29.826	56.8	41.5
15	30.181	30.150	30.073	30.077	65.0	45.3	15	29.740	29.694	29.796	29.932	63.5	46.8
16	30.029	29.998	29.902	29.867	66.8	53.0	16	29.666	29.934	29.934	29.910	55.5	44.0
17	29.811	29.872	29.868	29.907	60.1	51.1	17	29.838	29.804	29.677	29.533	54.5	38.1
18	29.922	29.934	29.956	30.032	63.3	44.1	18	29.541	29.653	29.766	29.822	56.1	50.0
19	29.938	30.036	29.985	29.984	64.1	41.6	19	29.756	29.696	29.652	29.642	57.8	48.2
20	29.926	29.912	29.800	29.767	70.8	53.0	20	29.590	29.624	29.634	29.672	67.5	53.2
21	29.635	29.605	29.576	29.697	68.1	58.1	21	29.632	29.612	29.466	29.420	56.4	52.8
22	29.744	29.842	29.881	29.975	65.3	52.1	22	29.444	29.454	29.464	29.632	64.7	48.2
23	29.959	29.953	29.896	29.975	63.3	48.1	23	29.650	29.772	29.834	29.922	63.2	51.0
24	30.054	30.148	30.164	30.228	66.3	50.8	24	29.926	29.970	29.960	29.976	58.0	50.9
25	30.231	30.242	30.192	30.222	75.1	53.2	25	29.952	29.980	29.966	30.030	58.3	50.7
26	30.196	30.195	30.109	30.080	75.8	48.1	26	30.062	30.116	30.058	30.004	61.3	45.8
27	29.994	29.989	29.913	29.923	75.8	47.2	27	29.912	29.862	29.800	29.750	59.3	48.2
28	29.840	29.831	29.758	29.686	68.8	51.7	28	29.612	29.508	29.354	29.288	64.2	52.2
29	29.620	29.687	29.699	29.791	63.8	57.9	29	29.370	29.332	29.245	29.409	57.7	46.3
30	29.765	29.788	29.753	29.612	64.3	51.6	30	29.465	29.527	29.550	29.572	54.4	43.2

OCTOBER, 1874.

1	29.422	29.478	29.447	29.489	67.4	56.1	1	29.508	29.438	29.388	29.276	53.8	42.7
2	29.521	29.344	29.266	29.310	59.6	48.4	2	28.930	28.820	28.778	28.772	51.2	43.9
3	29.274	29.355	29.391	29.465	57.5	43.5	3	28.718	28.806	28.970	29.010	51.0	43.9
4	29.441	29.365	29.382	29.628	53.8	48.0	4	29.054	29.166	29.307	29.469	51.0	41.3
5	29.784	29.937	29.999	30.050	55.8	39.3	5	29.601	29.721	29.750	29.718	49.6	36.4
6	30.000	29.855	29.726	29.542	56.0	35.0	6	29.494	29.228	29.054	29.010	51.8	43.2
7	29.326	29.226	29.448	29.649	58.6	52.1	7	29.004	29.060	29.242	29.524	51.6	43.2
8	29.815	29.940	29.940	29.931	55.4	40.0	8	29.696	29.780	29.721	29.579	52.0	34.9
9	29.842	29.836	29.879	29.999	59.3	40.0	9	29.355	29.505	29.630	29.670	54.8	44.7
10	30.041	30.082	30.083	30.117	60.1	40.9	10	29.598	29.684	29.745	29.827	55.8	44.3
11	30.112	30.141	30.105	30.164	60.3	50.6	11	29.761	29.757	29.750	29.751	55.7	41.9
12	30.153	30.153	30.070	30.025	64.4	50.4	12	29.895	29.877	29.797	29.763	53.9	40.8
13	29.919	29.887	29.847	29.886	66.6	49.4	13	29.693	29.861	29.915	29.949	54.8	39.8
14	29.893	29.849	29.714	29.635	60.7	52.1	14	29.837	29.717	29.531	29.423	53.7	47.1
15	29.478	29.443	29.421	29.486	65.0	55.1	15	29.277	29.207	29.291	29.237	56.7	46.9
16	29.539	29.676	29.786	29.843	59.0	50.4	16	29.425	29.589	29.654	29.624	55.8	42.8
17	29.853	29.853	29.841	29.890	58.7	46.2	17	29.438	29.366	29.303	29.521	59.7	43.9
18	29.934	29.984	29.930	29.914	61.2	49.3	18	29.545	29.575	29.472	29.564	57.7	50.2
19	29.819	29.887	29.914	30.043	58.8	50.1	19	29.468	29.428	29.738	29.808	52.3	41.3
20	30.155	30.254	30.195	30.132	55.3	39.9	20	29.904	29.804	29.697	29.503	52.7	40.8
21	29.806	29.569	29.565	29.672	57.8	47.2	21	28.826	29.053	29.330	29.420	54.8	39.2
22	29.688	29.718	29.701	29.756	52.7	41.9	22	29.474	29.524	29.596	29.702	49.5	40.9
23	29.821	29.952	30.035	30.106	51.7	35.5	23	29.790	29.872	29.902	29.906	48.8	34.8
24	30.126	30.140	30.089	30.060	55.2	42.2	24	29.852	29.814	29.680	29.502	53.3	43.2
25	29.955	29.960	30.005	30.109	58.8	45.6	25	29.330	29.452	29.634	29.880	58.7	46.0
26	30.123	30.130	30.075	30.055	60.4	54.2	26	29.972	29.950	29.827	29.791	51.4	36.0
27	30.034	30.023	30.011	30.052	62.5	52.9	27	29.751	29.809	29.893	30.009	54.3	38.5
28	30.012	30.018	29.973	30.063	61.8	53.7	28	30.061	30.125	30.087	30.109	50.3	34.5
29	29.981	30.009	29.994	30.045	57.4	48.9	29	30.093	30.163	30.181	30.281	51.8	31.1
30	30.055	30.125	30.168	30.248	54.0	49.5	30	30.321	30.381	30.392	30.424	51.0	35.9
31	30.228	30.259	30.221	30.220	52.5	49.9	31	30.388	30.400	30.321	30.305	40.6	32.1

BAROMETER AND THERMOMETER READINGS.

7

BAROMETER READINGS, &c.

NOVEMBER, 1874.

KEW.							GLASGOW.						
BAROMETER.					TEM- PERATURE.		BAROMETER.					TEM- PERATURE.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maxi- mum.	Mini- mum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maxi- mum.	Mini- mum.
1	30.186	30.191	30.152	30.149	50.5	42.5	1	30.251	30.253	30.202	30.186	42.0	30.1
2	30.095	30.080	30.042	30.063	54.7	45.1	2	30.072	29.990	29.894	29.876	50.7	40.9
3	30.075	30.119	30.092	30.151	57.0	47.6	3	29.860	29.828	29.731	29.819	54.5	46.8
4	30.135	30.175	30.133	30.129	57.0	34.1	4	29.833	29.879	29.851	29.823	57.2	47.4
5	30.100	30.106	30.054	30.095	56.6	42.7	5	29.795	29.873	29.933	29.975	55.4	44.6
6	30.125	30.217	30.239	30.289	59.8	48.0	6	30.045	30.125	30.117	30.087	51.8	34.7
7	30.320	30.410	30.441	30.491	54.3	42.9	7	30.055	30.197	30.254	30.272	53.3	41.0
8	30.485	30.518	30.453	30.448	52.3	29.3	8	30.250	30.246	30.236	30.238	56.8	45.2
9	30.413	30.388	30.271	30.211	57.1	35.5	9	30.204	30.118	.....	29.881	58.2	49.7
10	30.108	30.101	30.111	30.169	53.6	48.0	10	29.937	30.055	30.105	30.271	55.7	33.9
11	30.150	30.135	29.984	29.923	42.3	32.7	11	30.105	30.057	30.026	30.044	39.5	30.3
12	29.895	29.947	29.981	30.004	41.0	30.0	12	30.056	30.096	30.033	29.937	43.3	28.2
13	29.880	29.790	29.813	29.966	45.7	34.5	13	29.817	29.953	30.010	30.088	47.2	37.2
14	30.055	30.156	30.128	30.124	43.7	35.0	14	30.074	30.074	29.995	29.935	50.3	37.2
15	30.045	29.953	29.800	29.663	49.4	32.3	15	29.749	29.733	29.560	29.500	51.3	40.3
16	29.600	29.711	29.688	29.500	54.2	42.9	16	29.488	29.514	29.369	29.423	45.1	35.1
17	29.579	29.747	29.883	29.965	56.3	46.0	17	29.501	29.683	29.770	29.744	47.0	37.9
18	29.885	29.854	29.772	29.813	55.9	42.9	18	29.666	29.590	29.606	29.594	49.8	39.2
19	29.805	29.764	29.629	29.696	51.3	47.6	19	29.550	29.472	29.468	29.598	50.0	39.2
20	29.730	29.864	29.940	30.023	47.8	40.7	20	29.746	29.870	29.937	30.011	46.4	36.2
21	30.059	30.131	30.122	30.131	36.3	29.7	21	30.027	30.071	30.068	30.066	45.2	34.3
22	30.100	30.099	30.050	30.030	33.5	27.5	22	30.020	29.990	29.950	29.974	40.4	30.2
23	30.035	30.086	30.115	30.165	40.7	28.1	23	30.006	30.054	30.063	30.063	38.8	32.3
24	30.160	30.189	30.134	30.113	34.8	26.8	24	30.043	30.013	29.929	29.867	42.4	37.2
25	30.009	30.003	29.901	29.852	39.7	28.3	25	29.729	29.643	29.529	29.531	43.9	39.3
26	29.825	29.890	29.844	29.801	34.4	31.7	26	29.597	29.639	29.611	29.549	43.9	39.1
27	29.705	29.693	29.646	29.631	36.7	28.4	27	29.505	29.523	29.534	29.540	41.8	31.9
28	29.575	29.570	29.472	29.240	42.8	30.6	28	29.512	29.478	29.351	29.171	35.7	29.1
29	28.770	28.614	28.893	29.034	53.4	35.5	29	28.907	28.773	28.695	28.609	41.2	34.2
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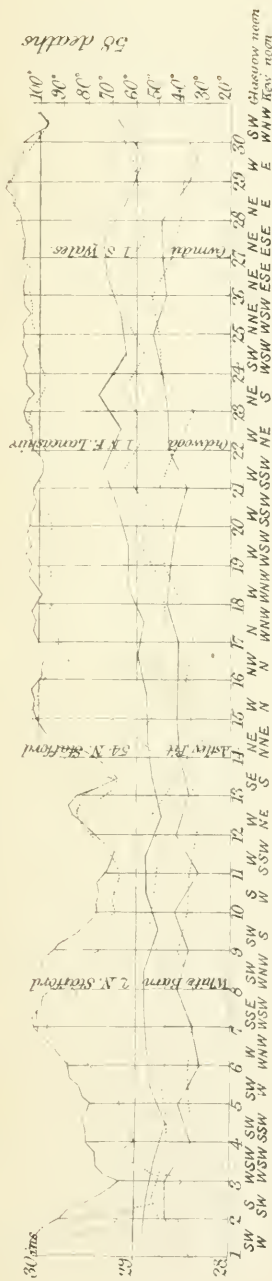
DECEMBER, 1874.

1	29.115	29.320	29.466	29.591	43.0	38.0	1	29.331	29.507	29.548	29.664	41.2	29.8
2	29.670	29.816	29.910	30.022	36.3	28.0	2	29.798	29.916	29.924	29.946	36.9	27.2
3	30.075	30.143	30.123	30.146	38.3	24.0	3	29.910	29.842	29.890	29.962	44.1	27.3
4	30.115	30.117	30.010	29.920	37.8	28.1	4	29.860	29.668	29.467	29.433	48.0	35.7
5	29.800	29.738	29.723	29.750	50.8	36.2	5	29.381	29.387	29.352	29.290	47.7	36.4
6	29.650	29.502	29.270	29.623	53.0	40.5	6	29.242	29.214	29.128	29.342	50.7	32.2
7	29.755	29.920	29.954	30.018	42.3	35.2	7	29.450	29.478	29.661	29.845	40.4	31.2
8	29.955	29.718	29.195	28.881	51.7	35.8	8	29.607	29.353	28.903	28.903	40.7	30.2
9	28.600	29.051	29.414	29.591	50.3	41.1	9	29.177	29.337	29.461	29.577	41.2	29.4
10	29.675	29.731	29.711	29.620	37.2	29.0	10	29.629	29.685	29.596	29.286	33.3	23.1
11	29.195	28.824	28.669	28.670	47.0	28.5	11	28.856	28.640	28.652	28.850	37.8	28.7
12	28.800	28.995	29.101	29.209	40.8	38.0	12	29.082	29.272	29.405	29.478	40.8	32.8
13	29.273	29.340	29.434	29.619	40.1	37.0	13	29.571	29.687	29.787	29.913	38.8	29.8
14	29.700	29.833	29.909	29.995	37.3	34.0	14	30.001	30.083	30.084	30.118	40.5	26.9
15	30.040	30.076	29.982	29.753	33.7	28.4	15	30.076	29.982	29.730	29.552	36.7	19.2
16	29.475	29.578	29.689	29.818	33.8	31.0	16	29.632	29.910	30.051	30.171	37.8	22.0
17	29.950	30.054	30.105	30.182	35.4	29.0	17	29.255	30.335	30.323	30.287	34.5	17.3
18	30.185	30.204	30.144	30.041	35.6	30.5	18	30.127	29.937	29.777	29.845	45.0	24.8
19	29.900	29.861	29.787	29.754	39.7	30.4	19	29.851	29.861	29.810	29.730	42.4	32.2
20	29.655	29.584	29.470	29.406	36.8	26.6	20	29.628	29.568	29.512	29.530	40.4	31.8
21	29.423	29.521	29.523	29.586	34.5	29.1	21	29.512	29.500	29.482	29.644	40.3	28.2
22	29.650	29.760	29.807	29.889	30.3	21.3	22	29.730	29.778	29.826	29.912	35.8	25.2
23	29.940	30.005	29.959	29.875	24.8	19.0	23	29.912	29.882	.....	29.621	30.9	20.0
24	29.700	29.498	29.480	29.616	36.8	21.3	24	.....	29.514	.....	29.567	34.7	21.2
25	29.715	29.758	29.710	29.759	36.0	33.2	25	.....	29.688	29.700	29.762	30.5	18.9
26	29.877	30.004	30.015	3.016	33.3	27.0	26	29.812	29.878	29.949	30.021	31.7	20.2
27	30.060	30.153	30.170	30.231	33.6	29.5	27	30.089	30.129	30.113	30.169	31.7	17.6
28	30.225	30.246	30.223	30.270	32.3	27.4	28	30.199	30.207	30.176	30.180	29.6	15.2
29	30.233	30.231	30.213	30.220	32.6	25.7	29	30.182	30.170	30.238	29.2	11.9
30	30.271	30.282	30.235	30.238	29.7	18.0	30	30.331	30.251	34.2	19.2
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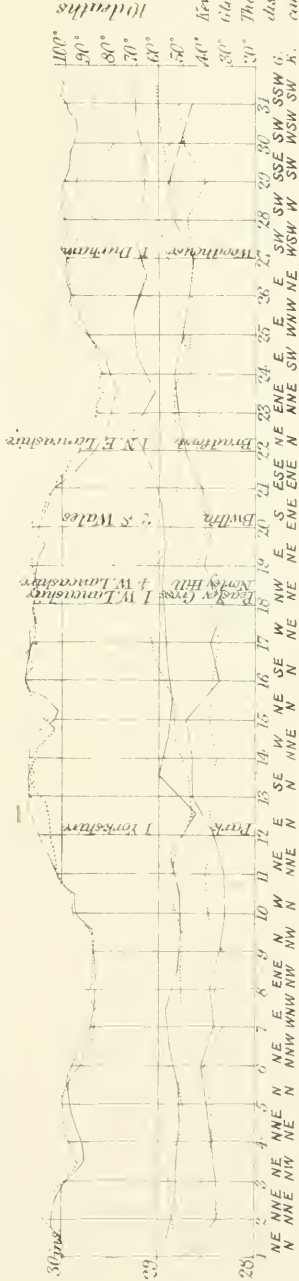
1874.

APRIL.

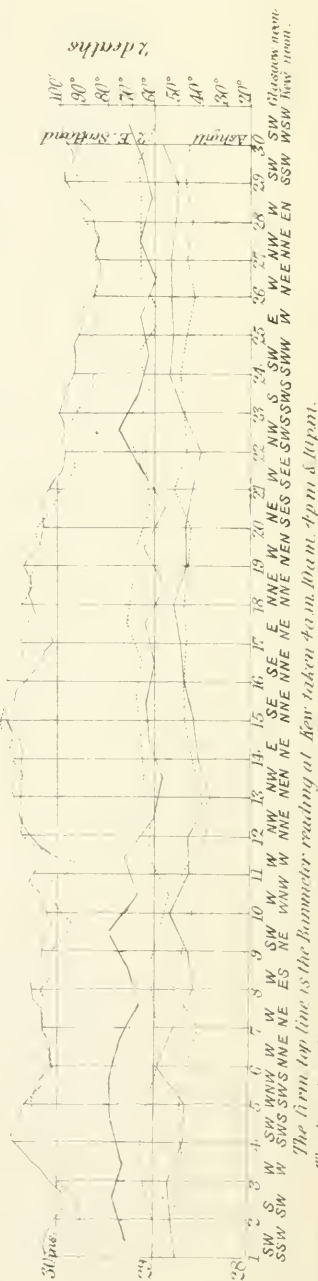
DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND



MAY



JUNE



Proceeding 10.1.2.4.4.4.

The dotted top line is the barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. 8 p.m.

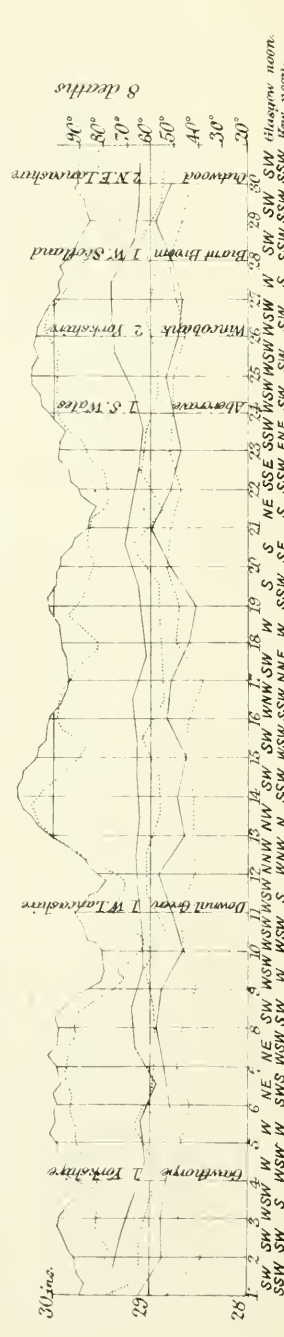
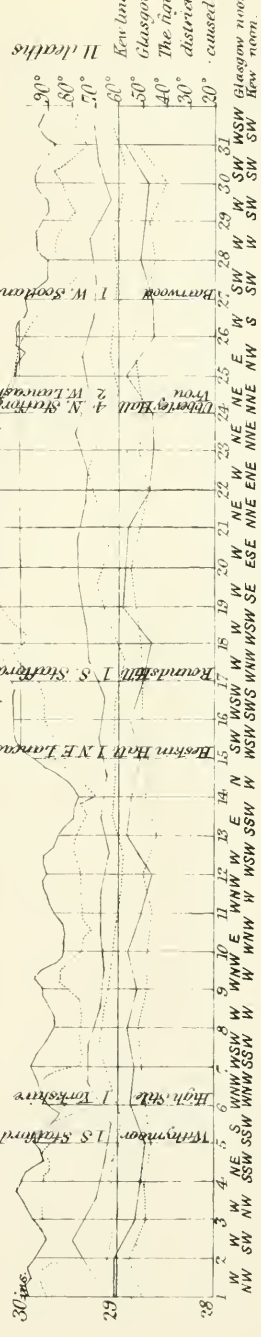
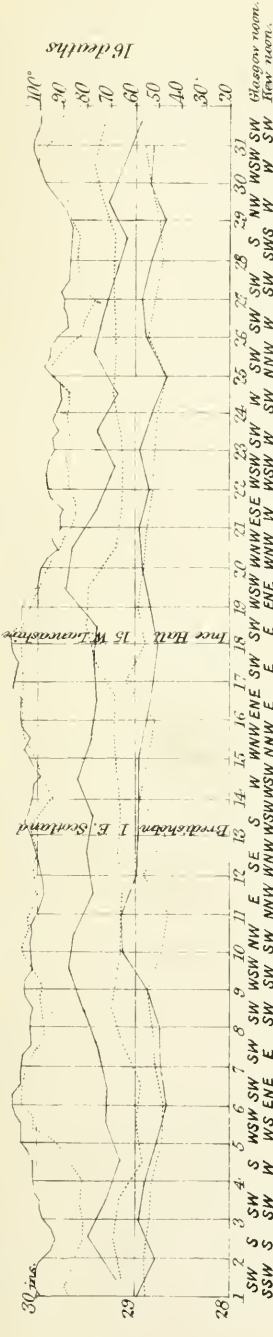
The lower lines are the barometer readings at Glasgow taken at 10 p.m. 8 a.m. 4 p.m. 8 p.m.

It has not been considered necessary to record the non fatal accidents this year.

DIAGRAM SHewing THE HEIGHT OF THE BAROMETER THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND

1874

JULY.



The firm top line is the barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.

The dotted top line is the barometer reading at Glasgow taken do. do. do.

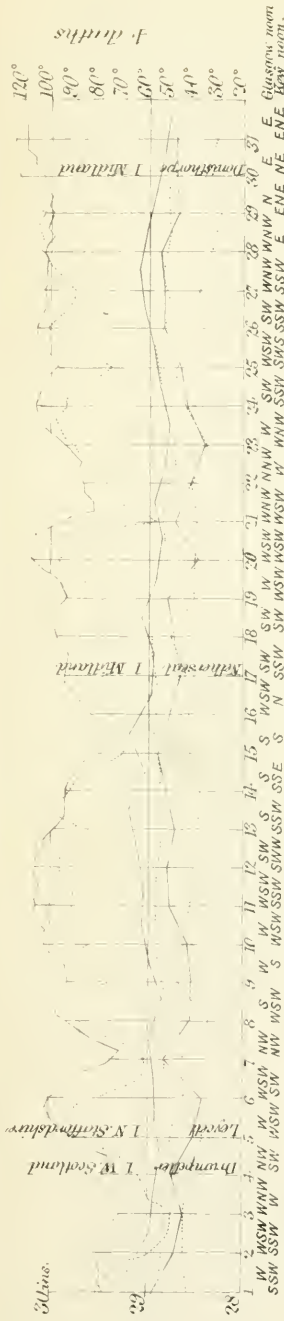
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 p.m. & 10 a.m.

It has not been considered necessary to record the non fatal accidents this year.

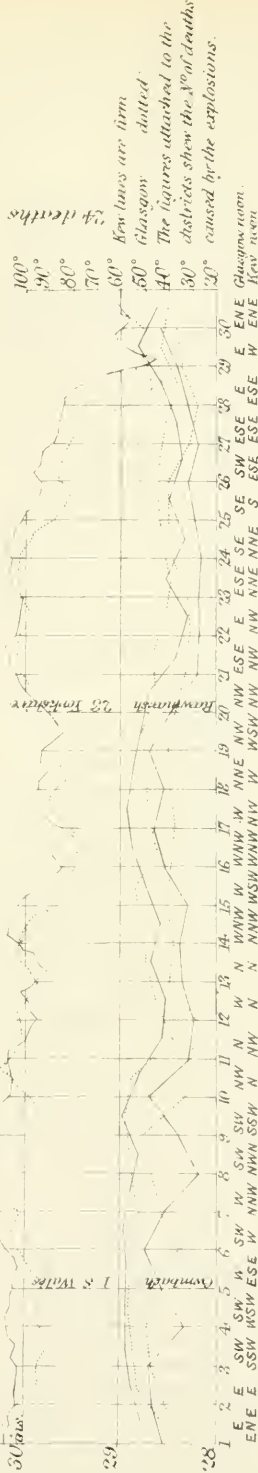
DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND

1874

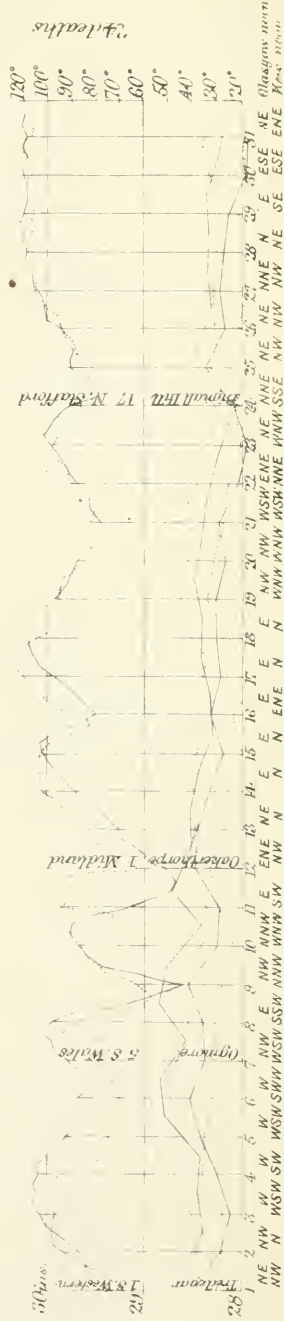
OCTOBER



NOVEMBER



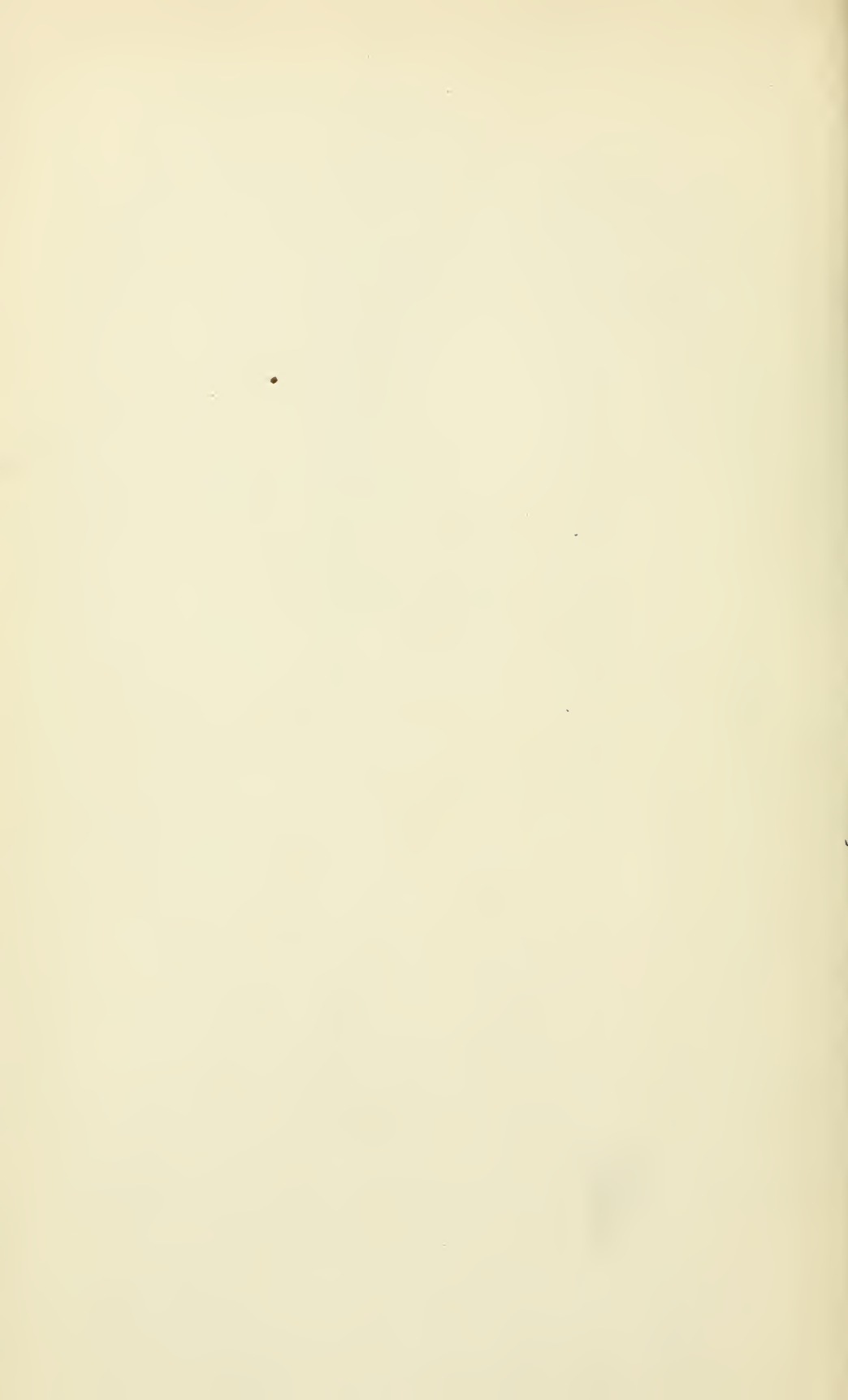
DECEMBER



The firm top line is the barometer reading at Kew taken 4 to 6 m. from April to 10 p.m.

The dotted top line is the barometer reading at Glasgow taken 4 to 6 m. from April to 10 p.m.

The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 p.m. & 10 a.m. It has not been considered necessary to record the rain & total accidents this year.



APPENDIX No. II.

A DESCRIPTION OF PATENTS

CONNECTED WITH

MINING OPERATIONS,

TAKEN OUT BETWEEN JANUARY 1, 1874, AND DECEMBER 31, 1874

BEING A CONTINUATION OF APPENDIX TO VOL. XXIV.

BY THE SECRETARY.

THE descriptions have been mostly given in the words of the patentee, all matter being excluded except that which is actually necessary to give some idea of the general principle involved. The exact details, if required, can readily be obtained from the Specifications. The patents are classified as before, viz. :—

- 1.—Lifting and winding, including safety-hooks.
 - 2.—Mining, boring, and sinking.
 - 3.—Pumping and modes of raising water.
 - 4.—Ventilation.
 - 5.—Safety-lamps and lighting mines.
 - 6.—Coal cutting, getting, and breaking down.
 - 7.—Explosive compounds.
 - 8.—Miscellaneous.
-

FIRST DIVISION.

LIFTING AND WINDING, INCLUDING SAFETY-HOOKS.

1874. No. 157. HUGHES.

The weight of the parts is made to assist springs in forcing claws into the guides.

1874. No. 358. JOHNSON.

An arrangement for preventing accidents in raising and lowering by causing the weight of the load to constantly and automatically apply a brake to the rope through the medium of a lever and to thus arrest its own motion, the removal

of the brake requiring the constant attention of an operator, any inattention on the part of whom can only result in the reapplying of the brake and the stopping of all movement.

1874. No. 2435. HUGHES.

An improvement on No. 157.

1874. No. 3186. HASELDINE.

Elevating coal from the ground and out of boats into trucks, &c.

1874. No. 3500. TAPLAY.

Levers pressing outwards when the rope breaks.

1874. No. 3588. TAYLOR.

Safety apparatus, chiefly applicable to cranes.

1874. No. 3785. ENRIGHT.

A disconnecting hook which disengages the weight when it touches the ground.

1873. No. 4042. DAVIS.

The cage is suspended by means of differential pulleys, provided with breaks; the description is unintelligible without a drawing.

SECOND DIVISION.

MINING, BORING, AND SINKING.

1874. No. 206. BALL.

Making the cross section of the bars from which drills are made in form of the cutting face of the drill.

1874. No. 563. TERREY.

Setting diamonds in drills, by providing the drill with a cap, in one piece or several sections, following exactly the form of the drill; the holes for the reception of the diamonds are made in this cap, tapering from its inner to its outer surface, so that when the diamonds are placed in these holes with their greater diameters in the inner side of the cap, and the cap is screwed or otherwise fixed on the body of the drill or tool, they cannot possibly fall out unless the diamond or the tool be actually broken, and in such case can be replaced by a diamond of the same size, instead of necessarily by a larger one, as required in case of ordinary setting.

1874. No. 503. DUNN.

Improvements in machines of that class in which the drill or perforating implement is carried and operated by a piston driven to and fro by the pressure of steam or other elastic fluid.

1874. No. 680. BOUSFIELD.

A machine in which the front portion, with the tool carrier and tool, is fixed to a hollow piston rod from a cylinder forming the rear portion. Air or other fluid under pressure is admitted into the back of the rear cylinder and tends to constantly press forward the hollow piston rod and front portion of the machine, and at the same time passes through it to a cylinder in front and gives to its piston a reciprocating motion, thus giving a jumping motion to the tool.

1874. No. 1149. BEAUMONT.

Relates to percussive rock drills, wherein the motion of the drill piston is effected by fluid pressure, admitted and exhausted by means of a piston valve, which is also moved by fluid pressure, controlled by the motion of the drill piston.

1874. No. 1162. HEATON.

Cutting chases in face of work, and breaking away the intermediate portions.

1874. No. 1181. WARSOP.

A reciprocating rock drill, where the tool is kept constantly against the surface to be cut.

1874. No. 1183. BELSHAM.

The use of an internal stationary core tube, which is pivoted to the socket of the ordinary boring tube. A current of water passes between the two tubes. As the crown cutter of the boring tube revolves and descends through the strata of coal or other mineral, a core is left in the internal tube, and this core is held in by steel wedges fitting in slots.

1874. No. 1278. BRYDON AND DAVIDSON.

A carriage for holding their patent rock drill, No. 1991, 73.

1874. No. 1438. WERDERMANN.

Application of intense heat to the rock to be perforated.

1874. No. 1489. BRYDON AND DAVIDSON.

The combination of a pump with a boring chisel, so that the borings may be carried off and the chisel kept free.

1874. No. 1603. MANSON.

Percussive rock drill, driven by air.

1874. No. 1676. CLARK.

The distinguishing features consisting, first, in the application of one or more diaphragms in the atmospheric hammer cylinder, whereby a very powerful machine is produced for boring rocks.

1874. No. 1724. DARLINGTON.

Percussive rock drill, in which the piston passes portways in the cylinder, or *vice versa*.

1874. No. 1714. MACINTOSH.

The use of chilled cast metal nibs or cutters applied to rock borers, the object being to substitute cutters of hard metal for the diamond cutters at present in use. Mortices are formed in the boring tube, and these cutting teeth are inserted therein.

1874. No. 1718. JOHNSON.

Percussive rock drill and stand.

1874. No. 1738. GREATHEAD.

A shield through stuffing boxes in which tools are protruded, the disintegrated material being suspended in water and forced back into suitable receptacles behind the shield.

1874. No. 1767. JORDAN.

Percussive rock drill in which the elastic fluid is supplied through the centre of the piston without the use of tappets.

1874. No. 2085. STURGEON AND WHITE.

Percussive rock drill.

1874. No. 2501. JOHNSON.

A rotating ring, having cutters on its periphery.

1874. No. 2728. TREGAY.

Improvements in boring rods.

1874. No. 2741. HASELTINE.

Percussive rock drill.

1874. No. 2760. HOSKING AND BRAKEWELL.

Percussive rock drill. The piston-rod has two pistons, and between them an annular piston forming the slide valve. There are no springs, ratchets, or tappets.

1874. No. 2790. HUNTRISS AND SWINBURN.

A central rotary cutter bar and outer cutter bar or bars, combining a rotary and lateral or circular motion of the outer bar with a longitudinal or backward motion of the frame containing the cutter bar.

1874. No. 2945. MACINTOSH.

Using hardened glass as a substitute for diamonds in boring machinery.

1874. No. 3038. BARLOW.

The boring apparatus consists of a cylinder with an annular piston, which is separate from the piston rod, but they move together when giving the blow, the cutter is fixed to the piston rod, and the position of the boring cylinder is governed by a piston in a hydraulic cylinder. The boring cylinder is supplied with compressed air or steam.

1874. No. 3299. WALKER.

A rock drill, driven by small compressed air engines.

1874. No. 3299. EDWARDS.

Reciprocating and percussive rock drill.

1874. No. 3386. WUBBEL.

The application of a free-falling rope or jumper movement to a novel arrangement of mechanism or apparatus composed of a central rod, an inner tube or hollow rod, and an outer tube or larger hollow bar for earth boring.

1874. No. 3397. THOMPSON.

Driving rock drills by connecting the drill spindle directly to the engine without intermediate gear.

1874. No. 3490. WIRTH.

A rotary steel implement working under high pressure, and by means of which hard rocks, as basalt and the like, can be bored without any appreciable wasting of the bit of the said implement.

1874. No. 3836. MUNRO.

A cutter made in the form of one half of a hollow truncated cone, held in a conical socket. The cutter fits a recessed part of the conical head of a spindle, and is prevented from turning by the shoulders of the recess, whilst the spindle itself is prevented from turning by a projection, on its entering a groove on the side of the socket.

1874. No. 4402. BEAUMONT.

Working rotating slides for percussive drills, by an auxiliary engine worked by the fluid which is employed to work the drill piston, the movement of the slides being thus rendered independent of the strokes of the drill. The tool is also advanced by a separate piston.

THIRD DIVISION.

PUMPING AND RAISING WATER.

1874. No. 58. BOUSFIELD.

Rotary pump to use steam expansively and secure the tightness of the packing.

1874. No. 84. BROOKES.

The plunger is made hollow and fitted with a valve at its foot. This valve opens out from the interior of the plunger and forms the suction valve of the pump. A suitable distance up the hollow ram there is a through slot of length corresponding with the stroke of the pump, and of width corresponding with the diameter of the suction pipe which enters the barrel of the pump opposite the slot. The plunger is fitted below the through slot with spring packing rings which are placed round the plunger and between the valve at the foot of the plunger and the through slot. The delivery or discharge valve of the pump is fitted at the foot of the pump, and may be of any suitable form.

1874. No. 121. BENSON.

Constructing pump valves of elastic material.

1874. No. 203.

As far as it relates to pumping it consists in making the valves and seats so that they can be separately examined.

1874. No. 239. BROADFOOT.

Attaching a slot between the cylinder and pump for giving motion to the crank.

1874. No. 327. BUDENBERG.

Improvements in injectors.

1874. No. 403. LUMLEY.

Changing the steam valve by steam admitted to a valve cylinder by the action of the main piston.

1874. No. 404. CHERRY.

A loaded valve is placed on the suction pipe for the purpose of producing a vacuum into which the exhaust steam is discharged.

1874. No. 840. COOK.

Rotating pump.

1874. No. 873. NEWTON.

The invention consists in a valve box fitted to turn on or around its axes within the pump case and in suitably shaped passage in said case and around the valve box, whereby in all positions of the pump a free communication is established with the under or inner side of the valve, while its upper or opposite side is closed to such communication.

1874. No. 932. PICKERING.

Direct-acting steam pumps, the valves of the engine moved by steam pressure without the use of tappets.

1874. No. 972. MIRLEES.

The combination of the engine known as Robertson's engine with the air pump, constituting a new pumping engine for forcing liquids.

1874. No. 979. PRALL.

Using compressed air for elevating water.

1874. No. 1043. COLEBROOK.

Making pump valves of several pieces of canvas or leather in such a way as to form a figure of a X in cross section.

1874. No. 1106. BREMME.

A gear for working the slide valves of steam pumps, and consists in actuating the valve spindle by means of a combined lever and disc. The lever is so arranged and combined with the disc that its fulcrum is changed and its action reversed during the same stroke. The lever may be worked by a link connecting it to the piston rod of the engine or otherwise. The peculiar feature of novelty in the combination of the lever and disc is that the lever changes its action during the same stroke; that is, in the first part of the stroke it is a lever of the second kind, that is, the weight is between the fulcrum and the power. During the same stroke it becomes a lever of the first kind; that is, the fulcrum is between the power and the weight. This change reverses the action of the lever during one stroke.

1874. No. 1135. WEBB.

An improved construction of injector, in which, instead of making what are termed the discharging and receiving "cones" in two distinct parts with a space or break between them to form an overflow, the two nozzles or cones are made continuous and without break or overflow orifice or chamber.

1874. No. 1189. PATTISON.

Hydraulic pumps of common construction convey water pressure to a distance to an improved apparatus for pumping air or water, fitted with automatic valve gear. Means described for regulating fluctuations of pressure in pipes.

1874. No. 1256. SAFFIELD.

Making pump barrels of several slabs of glass held together by bands.

1874. No. 1286. LAKE.

In arranging the air-vessel over and between two pumps, to form the fulcrum for the lever, in combination with a water way connecting the open ends of the pumps with the delivery pipe and check valve, the piston rods passing through stuffing boxes at the top of the water way, and connected by slots and friction rollers with the brake or lever.

1874. No. 1360. JOHNSON.

A right and left handed screw fixed on the same axle and revolving in a cylinder, the ends of which are open or partly open, and with another opening in the centre of the cylinder corresponding to the line where the two screws meet. When the double screw is turned round, it either draws fluid in at each end and forces it out at the centre, or *vice versa*.

1874. No. 1490. LEE.

In putting the barrel close to the blast holes at the bottom of the pump. In contracting the top part of the barrel.

1874. No. 1707. KENNARD.

Improvements connected with the construction of sand pumps.—Cannot be described without a drawing.

1874. No. 1711. BEALE.

Two or more vanes or pistons are carried round the interior of a cylinder by the action of an eccentric axle or drum, such vanes or pistons being maintained in

their course by guide blocks fixed thereto, and working in annular grooves formed in the end plates of the cylinder and concentric therewith.

1874. No. 1815. KENNARD.

Improvements in sand pumps.

1874. No. 1868. ORAM.

An arrangement for liberating the motive power from pressure when it is not required.

1874. No. 1957. HAZLEHURST.

This invention relates to pumping liquids by the peculiar use of a diaphragm, or collapsable bag or pipe of any suitable form.

1874. No. 2078. TIPPING.

Dispensing with the present spears and substituting pipes up which the fluid is pumped. The lower end of the pipe so used as a spear is enlarged to form a plunger bucket of the diameter of pump required.

1874. No. 2185. GAMBONI.

Consists of pistons having bags on one or both faces working loosely in cylinders containing liquid or air under pressure to avoid surface friction.

1874. No. 2267. MURPHY.

Consists of the employment of an inlet and outlet pipe inserted into the receptacle containing the fluid, and by atmospheric pressure through the inlet pipe forcing the fluid up through the outlet pipe.

1874. No. 2315. BENTLEY.

Consists in raising water by means of a spiral being made to revolve by suitable gearing within a cylinder, the internal circumference of which being the same size as the spiral before mentioned, whereby a continuous stream is delivered.

1874. No. 2361. BREMME.

Actuating the valve spindle or rod by means of a lever which is attached at one end to the valve spindle by means of a link or its equivalent, and at the other end to the piston rod of the engine by means of a link.

1874. No. 2371. WALKER.

The inventor employs a double ended piston having a cylindrical part working in a partition piece. The steam is admitted into the annular space around the said cylindrical piece, and is then expanded into the larger steam space.

1874. No. 2428. MACKENZIE.

The steam cylinder is placed between the blowing cylinder and pump cylinder, the valve gearing of the steam cylinder being worked by plugs or rods, which are struck by the piston of the said steam cylinder. A condenser is combined with the pump cylinder, which condenser is put in connection with the exhaust pipe of the steam cylinder.

1874. No. 2563. CLARK.

The invention consists in the combination with a main cylinder having steam ports and a piston rod carrying a middle piston and two pistons of cylinders placed at opposite ends of main cylinder, having respectively water inlet and outlet, and connected by a channel way, a continuous flow of water at the exit being produced.

1874. No. 2666. MUSHET.

To the lower end of the barrel of an ordinary suction pump is attached a suction or

feed pipe, the united lengths of which barrel and pipe must not together exceed the height to which in practice a suction pump will raise a column of water. The lower end of the suction pipe passes into a covered reservoir or chamber and extends nearly to the bottom of the same. A second length of suction or feed pipe is inserted through the bottom of the reservoir or chamber and passes upwards to within a short distance of the top thereof. A similar arrangement of pipes and reservoirs or chambers is continued until the source of water is reached. The reservoirs or chambers are respectively supplied with water by any convenient means, a stratum of air remaining at the top of each reservoir or chamber. The pump is set in action in the ordinary manner, and the water is raised from the source of supply and discharged from the outlet of the pump barrel. A check valve or valves is or are placed in the suction pipes for the purpose of sustaining the column or columns of water, and thereby rendering the discharge from the pump more uniform than it otherwise would be.

1874. No. 3069. DRUCE.

Consists of two cylinders open at the top and having in them pistons connected by rods to a beam or jointed to main frames or standards. At the bottom of each cylinder there is a disc valve working in a valve box, and the two cylinders communicate with each other by a horizontal tube having in the middle a covered chamber, the tube having at each side seatings for a disc valve.

1874. No. 3164. BARKER.

A valve formed of two or more India-rubber rings around a perforated metal tube.

1874. No. 3193. HOLDEN.

The application of telescopic tubing to raising water, and in the fitting of appliances thereon for making the joints water-tight.

1874. No. 3361. BENSON.

The improvement consists in the structure and arrangement of the main and auxiliary steam valves and their connections with steam ports and passages for admitting and exhausting steam from the auxiliary cylinder for working the main steam valves of pumping engines.

1874. No. 3545. JOHNSON.

A right and left handed screw fixed on the same axle, revolving in a cylinder, the ends of which are open.

1874. No. 3549. HAMILTON.

This invention relates to the valves of the steam or compressed air cylinders of direct acting pumps, and consists in automatically working them in the following manner:—The valve consists of three parts, two short pistons at opposite ends of the steam chest, and a cylindrical hollow valve, with two ports in it, between the short pistons. By the reciprocating motion of the middle valve its ports are made alternately to convey steam to or permit of the escape of exhaust from the same end of the cylinder. Two small ports near the ends of the steam cylinder open into the steam chest, and admit steam at the proper times behind the end piston valves. As the steam piston makes its stroke, it opens one or other of the small ports, and steam entering the steam chest acts upon the end piston valve, and the latter advances the middle cylindrical valve and reverses the position of its ports, the entering

steam forcing in opposite directions the said middle valve and end valve so as to completely open both the steam and exhaust ports.

1874. No. 3567. ASHWORTH AND ASHWORTH.

Making ram pumps double acting by employing a single ram, which works in two ram chambers, each provided with a gland or stuffing box.

1874. 'No. 3621. WILKS.

The arrangement of the ports in a cylindrical slide valve and valve casing, for causing the valve to change from one end of the valve chamber to the other, so as to direct the flow of steam to alternate ends of the main cylinder, and cause the desired reciprocation of the piston and rod.

1874. No. 3658. PARKER AND WESTON.

Constructing the valves of pumps and engines in the following manner:—Two exhaust valves, two steam valves, and two pistons are arranged on a rod working in a steam chest furnished with seats for the steam and exhaust valves. One piston, one exhaust valve, and one steam valve are arranged on either side the middle point of the rod. The exhaust valves are of greater area than the steam valves. Small ports are made in the ends of the steam chest, in addition to the steam and exhaust ports. As the piston approaches one end of the steam cylinder, the small port is opened and steam is admitted to the back of the exhaust valve, and the exhaust valve at that end is thereby closed and the steam valve opened, the exhaust valve at the other end of the steam cylinder being opened and the steam valve closed. The same action takes place when the steam piston approaches the opposite end of the cylinder. The movement of the valve is produced by the action of the steam on the exhaust valve, the area of which is greater than that of the steam valve.

1874. No. 3661. HOOKER AND BROWN.

The construction of a direct-acting steam engine working on the compound principle, which will measure its stroke, start at any point in its stroke, and waste no steam in any of its functions. Also an apparatus for regulating the supply of steam to an engine. Also an improved pump valve actuated by a steam engine, and a novel means of lining the cylinder of a pump worked by said engine, which liner can readily be removed and replaced.

1874. No. 3719. PAGET.

Improvements in centrifugal pumps.

1874. No. 3807. JOHNSON.

This invention relates to raising water or other liquids to the height of ordinary pumps, or the height of a column of water balanced by the atmospheric pressure, and to the "fetching" or charging instantaneously with such water or other liquid of injectors, suction apparatus, liquid elevators, and the like.

1874. No. 3917. PRESTON, PRESTIGE, PRESTON, AND FOWLER.

This consists in fitting one or more pistons combined with one or more buckets in a pump barrel, so that each piston has the effect of a double-acting pump, and each bucket the effect of a single-acting pump, without the intervention of any fixed covers between the pistons or between the pistons and buckets.

1874. No. 3938. EVANS.

The pump valves are actuated from the same eccentric or equivalent as is used to actuate the steam valve, or in the case of two pumps working opposite to each

other, actuating the valves for both pumps from the same eccentric or equivalent on the revolving shaft.

1874. No. 3960. HULME AND LUND.

This invention refers to "donkey pumps," and consists in an application of an air chamber to the bed plate.

1874. No. 4129. WALKER AND PFLAUM.

Improvements in pumping, employing a heavy weight running on wheels or supported by levers, and attached to the piston rod of the engine (which is horizontal) and also to the plunger of the pump.

1874. No. 4164. DAVISON.

This invention relates to the removal of dead centres in crank shafts, and is effected by keying on to a straight longitudinal shaft, supported in journals, a hollow barrel with solid ends. This barrel is divided diagonally and spirally into two portions, and so set apart from each other as to permit a pin to travel to and fro on the shaft and between and along the divided edges of the two portions. Connected to the external end of the pin is an upright arm fixed to the cross-head that works on a centre below the barrel. When the pin is driven to and fro along the shaft by the revolution of the barrel, the pin carries with it the upright arm of the cross-head, causing the same to oscillate, and by that means giving motion to the pump-rods attached to the two horizontal arms of the cross-head.

1874. No. 4212. WOLSTENHOLME AND THORPE.

The steam valve is moved by a lever which slides in a sleeve which is carried by the piston rod. Small pistons acted upon by the pressure of the water are employed to regulate the throttle valve and break, and thereby to govern the piston speed.

1874. No. 4213. ASHWORTH AND ASHWORTH.

The inventors employ a double-acting ram working in two chambers separated by a stuffing box. The gland is tightened by means of bolts or screws passing through stuffing boxes.

1874. No. 4297. BINNIE.

Discharging the steam into the suction pipe of the pump through an annular passage, for bringing the whole of the steam as much as possible in direct contact with the water.

1874. No. 4490. ANDERSON.

Improvements in centrifugal pumps.

FOURTH DIVISION.

V E N T I L A T I O N .

1874. No. 840. COOK.

Two moveable rotating pistons, mounted on separate shafts, but rotating round the same axis, and acting independent of each other. To each of these pistons an alternate fast and slow motion is communicated, so that while one piston passes rapidly eleven-twelfths of a circle, the other slowly passes over the other twelfth,

1874. No. 1360. JOHNSON.

See pumping.

1874. No. 1711. BEALE.

Two or more vanes are carried round the interior of a cylinder by the action of an eccentric axle or drum.

1874. No. 1749. BALL.

Compressing air by an arrangement of steam engine driving a crank pin upon a heavy fly wheel, upon which crank pin also works a connecting rod which drives a piston in a pump arranged at an angle to the steam engine. This pump is single-acting having one end open, and is fixed in a cistern of water which has access to the inside and outside of the pump. The pump piston is adjustable so as to work close down to a cover to which are fitted inlet and outlet valves. The inlet valve is connected to a tube into which water in the form of spray is driven by a jet of air.

1874. No. 3047. JOHNSON.

In drawing at every stroke of the actuating piston a fresh quantity of water which forms a cooling medium for the air whilst being compressed. In entirely obviating injurious spaces. In the employment of a body of liquid which is maintained at a constant level at the joints for the purpose of preventing any leakage.

1874. No. 3134. MORRISON.

This invention refers to ventilators, fans, and blowing machines, which consist of a casing having one or more inlets and outlets, and of blades made to revolve in the casing, so as to draw in air at one part and discharge it at another part. The Provisional Specification describes the construction of blades so that they widen out towards their periphery, and are slightly curved in a forward direction; also the making of the inlet or inlets of funnel shape or conical; also where there are inlets on both sides of the casing the employment of a disc in the middle of the fan to prevent the opposite currents interfering with each other.

1874. No. 3135. NELSON.

One part of this invention refers to those ventilators, fans, or blowing apparatus, which consist of a cylindrical casing having an outlet or chimney of evasé form provided with a regulating shutter, and of a revolving fan, the blades of which are fixed to a series of reciprocally crossing arms. The Provisional Specification describes a mode of constructing these ventilators, fans, or blowers, in portable form. The engine for driving the fan is mounted on the casing which forms the bed plate thereto, and the fan is driven by spur or frictional gearing. The whole is mounted on wheels. The inlet or inlets to the fan are of funnel shape or conical, the wider end being outermost. The fan can thus be made either to blow or to exhaust.

Another part of the invention consists of a novel arrangement and disposition of fans or blowers for blowing smiths' or forge fires. The Provisional Specification describes the employment of a small separate fan for every fire, the blast or outlet pipe being inserted directly into the tuyere; these fans are driven by small straps from pulleys on a shaft placed as close as convenient to the fire. By these means the waste caused by leakage and otherwise when the blast for

all the fires is produced by a single blowing machine, as in existing arrangements, is avoided; the breaking of one strap does not throw more than the one fire out of work, and when one or more fires are out of work the power required for driving the shaft is diminished in proportion. The Provisional Protection also describes the manner in which it is preferred to construct the fans or blowers.

1874. No. 3471. KÖRTING.

A jet apparatus is worked by steam or other agent by means of differential or graduated mixing nozzles combined with a diverging tube. A regulating valve is used. A perforated pipe or a false bottom is used and a connection made to produce a partial vacuum.

1874. No. 3505. KÖRTING.

Worked by a jet of steam and provided with graduated mixing nozzles and a diverging tube. The nozzles are conical, so that the space between consecutive nozzles is largest at the air inlets.

1874. No. 3719. PAGET.

Guiding the fluid into the vanes of a revolving wheel by means of a curved central directing plate.

1874. No. 4084. NEWTON.

This invention relates to the compression of air by and in the presence of water, whereby it will, while undergoing compression, be robbed of a great part of its latent heat, and in consequence will on liberation be applicable for cooling and ventilating.

1874. No. 4190. LAKE.

An arrangement which permits of giving large sections to the suction valves to obtain a considerable wet surface in the interior of the compressor with a minimum quantity of water and thereby permit with safety a maximum velocity of the piston.

FIFTH DIVISION.

S A F E T Y L A M P S .

1874. No. 699. PILKINGTON AND ADDISON.

Consists principally of a spring bolt or latch working inside a small cylinder or tube, and locking the lamp automatically when the lamp top is screwed down into its place, which spring bolt cannot be withdrawn excepting by a person in possession of a special key adapted for the purpose.

1874. No. 768. LANDAU.

Lamps with annular chambers and perforated rims for circulation of air, parts being without perforations, and openings being made in the chamber for circulation of air. A removeable oil chamber is used in miners' and other lamps. Bayonet joints or similar contrivances are used for connecting the upper and lower portions of lamps together. Extinguishing plates and other arrangements are described.

1874. No. 2579. CLARK.

The object of this invention is to provide a lamp or lantern for miners' use, and consists of a lamp provided with a mica chimney or casing, at the upper and lower ends whereof are sections of wire gauze or finely perforated metal of corresponding shape, and in so uniting or connecting said sections and casing to each other and to the lamp that the union shall be very tight and secure.

1874. No. 2914. TEALE.

To provide greater security against the opening of lamps while a light is burning therein by means of an extinguishing tube which is brought over the light before the lamp can be opened. To light lamps after being securely fastened by a current of electricity being passed through the inflammable vapour used in such lamps.

1874. No. 4254. ARMITAGE.

The safety lamp is provided with a perforated cover, which is soldered or otherwise secured to it. The wick of the lamp is ignited by a fine taper tube connected to a gas burner, and the lamp is put out by an extinguisher which is held up by a spring lever.

SIXTH DIVISION.

COAL-GETTING.

1874. No. 132. NORRIS.

The machine is made with rotating compound cutters, so constructed together in rows as at a single operation to cut in the coal to be operated upon a groove as long as the row of cutters measuring in a line cutting the axes of the whole of the cutters at right angles to such axes. The machine is actuated by a handle or hand wheel carried by a quadrant adjustable to any angle, so as to facilitate working near the sides of a gallery.

1874. No. 1554. WILDE.

Consists in substituting for the force of compressed air or other power now employed for excavating coal and other minerals, the motive power produced by magnetism and electricity.

1874. No. 1741. HUNTER.

The arrangement and combination of the improved excavating machine with or without the use of a "monkey." The ram for driving or forcing the shovel-like blades into the soil to be excavated.

1874. No. 2171. EAGLESHAM.

The framework of the machine with driving gear is mounted on frames or runners on each end mounted on wheels, and is attached to said frames or runners by longitudinal bars from end to end under machine, to which are attached screws, wheels, or pinions, for purpose of setting machine at any angle required. Applying revolving cutters fixed to a revolving disc or plate, or attached to an endless chain, so as to reduce friction.

1874. No. 2501. JOHNSON.

The mining of coal by means of a rotating ring having cutters on its periphery, such

ring being carried by frame work so constructed and so adapted to ways that the ring may be raised and lowered, turned laterally, and moved in a horizontal plane in two directions, one at right angles to the other, and be thus caused to penetrate and cut channels in the rock or coal as desired.

1874. No. 3000. WILDE.

A portable machine in which a pick is moved to and fro by a capstan wheel to form the groove or undercut; the pick is raised and lowered to increase the depth of the cut by a screw; the whole machine is moved along a bed fixed to the floor of the mine.

1874. No. 3009. ALEXANDER.

This invention relates to mineral cutting machinery operating on the principles of that described in patents, Gledhill, No. 3063, of 1866, Gledhill, No. 3759, of 1869, and Alexander, No. 3438, of 1871; and comprises improvements in details and in the manner of arranging and combining the parts, the object being to simplify and strengthen the parts, and to render the machinery efficient and less liable to get out of order. A coal-cutting machine of the kind referred to operates by means of a series of cutters carried by an endless chain, this chain being stretched by a gib and moved by means of a cylinder or cylinders worked by compressed air or otherwise.

1874. No. 3237. HIGGS.

Hydraulic coal-cutting machinery, the return stroke of the piston or ram being effected by the resilience of a spring or of air which has been compressed by the forward or cutting stroke of the piston itself, a suitable valve arrangement being employed for releasing the water at the end of the stroke.

SEVENTH DIVISION.

EXPLOSIVE COMPOUNDS.

1874. No. 1275. CLARK.

The manufacture of cartridges of skin or gut treated with special preparations of collodion to render the same hard and impervious.

1874. No. 1558. DADDOW.

A fuse tube immersed or coated with soluble glass; in an adjustable match adapted to a mining squib; in a mining squib having one end contracted to form a vent; in a squib with a match permanently attached thereto; in an artificial straw squib capable of being used as a rocket or former squib; in a miner's squib charged with explosive shells, or balls; and in a hollow match having one end open for the insertion of the squib or fuse, and provided with a slow match.

1874. No. 1566. GOTTHEIL.

This invention consists in the employment of an explosive compound consisting of a solution of a hydro-carbon and an acid hydro-carbon in nitro-glycerine.

1874. No. 2062. MACKIE, FAURE, AND FRENCH.

Incorporating nitre or other oxidising substance with gun cotton.

1874. No. 2385. LLOYD.

The invention consists in increasing the disruptive power of an explosive substance by confining it within a resisting envelope, by which means a complete combustion is secured from the entire bulk of the contents being turned into gas before the envelope is ruptured, and a corresponding economy of explosive material is obtained.

1874. No. 2641. DAVEY AND WATSON.

In saturating gunpowder with hydro-carbons, such as a parafine in a liquid or gaseous state; and in compressing it into cartridges for mining purposes, chiefly by means of a special machine, the leading feature in which is a number of moulds wherein the hydro-carbonated powder is compressed by pistons actuated automatically and simultaneously from one source of motion.

1874. No. 3612. MACKIE, FAURE, AND FRENCH.

Using less acid than usual in the manufacture of gun cotton. After the conversion, the nitric acid of the waste acid is saturated with a base, thus forming a nitrate, the quantity of which is that just required to give the best effect when mixed with the gun cotton.

1874. No. 3781. FAURE AND FRENCH.

Incorporating together charcoal, nitrate of baryta, and nitro-cellulose, and making the same into discs or other forms supplied with a detonating charge; and some other means of producing and using a powder very strong when properly fired, but otherwise comparatively harmless.

1874. No. 3920. ROBY.

An improved means of storing powder.

1874. No. 3934. GRAY.

A new compound to be used as a blasting powder, and to be known by the name of carboazotine.

EIGHTH DIVISION.

M I S C E L L A N E O U S .

1874. No. 34. FORBES.

Artificial fuel.—Combines the foul lime of gas-works, or its equivalent, with coke, with or without chalk or limestone, with or without bituminous substance, and with or without hydro-carbon oil or spirit.

1874. No. 57. AITKEN.

Forcing or blowing heated or cold air into the space of coke ovens or kilns above the upper surface of the materials being coked, so as to burn the gases and promote the coking process. The arrangement or construction of coke ovens or kilns with a moveable bottom or top, or with both the top and the bottom being made moveable. Forcing or blowing carbonic oxide or other neutral gas into coke ovens or kilns whilst the coke is cooling, in order to prevent waste of coke.

1874. No. 326. LOWE.

Artificial fuel.—The dry sewage of the streets ground in a mill and mixed with a proper proportion of gas tar, charcoal, coal slack, and clay washings.

1874. No. 360. HAHN.

Artificial fuel.—The coal dust or small coal is first mixed with a small percentage of ground pitch or other like material and put into pans which pass into the oven, whence the mixture is taken to moulds connected to endless chains, which pass over wheels one above the other, and compress and deliver the material.

1874. No. 568. CORBETT.

Artificial fuel.—The fuel is composed of 5 lb. by weight of powdered charcoal, 6 lb. clay or clayey earth, 1 gallon of liquor into which 6 or 7 lb. dried cattle dung or peat have been stirred.

1874. No. 800. FORBES.

Artificial fuel.—A combination of chalk or the refuse lime of gas works, or its equivalent, with a mixture of common salt (chloride of sodium) and saltpetre (nitrate of potassa) or nitrate soda, or its equivalent, or (instead of the above mixture) with common soda (carbonate of soda) or its equivalent, with or without tar or similar bituminous substance.

1874. No. 857. LAKE.

This invention is designed for use by firemen and others in having access to or in escaping from burning buildings, or in the extinguishment of conflagrations when it is desirable to closely approach the flame, also by miners and others exposed to noxious gases, to a high temperature, or a dusty or noxious atmosphere.

1874. No. 889. TAYLOR.

Cleaning small coal or slack and for separating ores from their gangue.

1874. No. 976. MARRIOTT.

Artificial fuel.—Mix ashes and other refuse from dust-bins or such like with small coal and peat, which are incorporated with pitch, tar or other bituminous matter.

1874. No. 1280. PAGE.

Artificial fuel.—Mixing clay, lime, peat, starch, potatoes, or potato matter, nitrate of potash, carbonic acid, and Condry's fluid, or some of these substances, with the culm or coal-dust, and incorporating the mixture in a mortar mill.

1874. No. 1315. HEALEY.

Machinery for moulding and compressing patent fuel, iron ore, and bricks.

1874. No. 1408. WILLIAMS.

The manufacture of artificial fuel, whereby coal, coke, peat, or similar substances, when in a state of powder or fine division, or dust or duff, is heated so as to produce solid waterproof fuel of great commercial utility, particularly for steam purposes.

1874. No. 1567. LOWNE.

Improvements in anemometers.—Consist in making the communication from the fan, not by means of one axis as usual, but by two axes placed in a line separated by a diaphragm of metal, the communication of motion between the two being effected by means of a magnet revolving with the first axis, which carries the fan and a piece of soft iron placed on the second axis immediately behind the magnet, which is thereby caused to revolve with the fan, the axes are placed in jewels, the motion from the second axis conveyed by worm and wheels to the indicating apparatus as usual.

1874. No. 1689. ALSING.

Utilizing sewage deposits, night soil, and other dry and moist manurial matters, by mixing it with other carbonaceous, deodorizing, bituminous, and other suitable material, for the purpose of making it into a useful and cheap artificial fuel.

1874. No. 1826. GOODALL.

This consists—first, in the employment of certain chemicals to precipitate the solid matter of sewage; secondly, in the employment of lime and chemicals; and, thirdly, in the employment of the chemical precipitants, lime and small coal, to render the precipitate available for fuel.

1874. No. 1857. CASARTELLI.

Applying the graduated scale of miners' dials in the form of a semicircular arc or limb across the face of the compass box of the dial on swivel joints, in such a manner that it can be turned or folded down when not in use, and when raised to a vertical position for use, it does not obstruct the view through the sights.

1874. No. 1874. DE NOMAISON.

This invention relates to a process for purifying coke from sulphurous and other detrimental compounds. The combustible is heated to redness with exclusion of air, whereby the pyrites or bisulphide of iron which it contains is converted into protosulphide. It is then received in tanks containing water to which is added hydrochloric acid, which dissolves the protosulphide of iron, disengaging sulphuretted hydrogen, and also dissolves others of the earthy matters present. The coke is then washed with water and dried. The process is most readily effected upon small coke or dust, and it is therefore in some cases preferable to pulverize the material in the first place, and to agglomerate it into blocks after purification.

1874. No. 2142. KINGSFORD.

Mixing slacks of various coals, coke, or other carbonaceous materials with Portland or other hydraulic cements in suitable manner and proportion. Also to treating artificial fuels with coal tar, common pitch, asphalte, or other bituminous substances dissolved in hydro-carbon or mineral oil.

1874. No. 2287. BRECKON.

In manufacturing coke it has hitherto been customary to use only bituminous coal; this invention consists in manufacturing coke of a mixture of bituminous coal anthracite coal in about equal proportions, or in different proportions, according to the quality of the coals used or to the purpose for which the coke is required.

1874. No. 2396. DODDS.

Improvements in picks.—The pick head is made of iron somewhat shorter than the pick head is intended to be, the deficient portions at each extremity (not pointed) being supplied by steel points welded on to the body of the pick head constructed as above stated.

1874. No. 2494. AITCHISON.

Artificial fuel.—Combining peat with charcoai and the chlorides of calcium and sodium, which will combine with the phosphorus, sulphur, and other impurities contained in the ore or which may be found mixed with the iron.

1874. No. 2512. JOHNSON.

This invention relates to coke ovens constructed on the principle of what are known

as muffle furnaces, and consists essentially in a peculiar arrangement of the flues and other parts of the oven, whereby the emission of smoke during the operation of coking and the consequent inconvenience and annoyance to the neighbourhood in which the ovens are erected are entirely obviated.

1874. No. 3085. PENROSE AND RICHARDS.

This invention relates to the production of coke, and consists in the mixing or incorporating of anthracite or stone coal, or free burning steam coal, or coal known as Staffordshire slack, or other non-coking coals with bituminous coal, or any other coal capable of making coke, with pitch or tar, or with any form of tar or bitumen, mineral oils containing bitumen, petroleum, or any of the waste products of petroleum, such coal or coals being in a state of division. The mixture thus produced is to be placed in any well-known form of oven or retort commonly used for coking, and the surface is then to be covered with a layer of bituminous coal or other bituminous matter. (See also No. 3251.)

1874. No. 3200. PUNSHON.

Artificial fuel.—Petroleum is passed through perforated chalk, to which heat is applied. A condenser is employed between the reservoir of petroleum and chalk, to keep the petroleum in a liquid state as required.

1874. No. 3232. FORBES.

Artificial fuel.—Increasing the proportion of the saltpetre (or the nitrate of soda) employed with the common salt. Sometimes using a solution of nitrate of potash or nitrate of soda instead of common salt. Employing a compound of chalk and common salt and saltpetre for the production of lime.

1874. No. 3560. ORMISTON.

The arrangement or construction of the apparatus for coking coal or other carbonaceous substances and working the same, so that economy is effected by collecting the volatile substances.

1874. No. 3795. HACKNEY.

The production of an improved quality of coke, and consists in effecting the reduction to a fine state of division, by means of a "Carr's disintegrator," or by other means, of the materials from which the coke is to be made, namely, bituminous or caking coal, or any free burning coal or anthracite, or coke refuse, or other non-caking fuel (to be made into coke) after mixing it with powdered pitch, or with tar, or other binding material, and incorporating the same, or any mixture of them with lime, also in a fine state of division, and then submitting the mixture to a coking process, either in a retort or oven.

1874. No. 3880. DIXON.

The use of dextrine, fusil oil, and soda alum in the manufacture of artificial fuel composed of coke, peat, or small coal disintegrated.

1874. No. 4148. LEECH.

This invention relates to the construction of a signal apparatus for collieries, mines, and other underground works, the object of the invention being to combine visible and audible signals from the persons at the bottom of the shaft to the engineer at the pit mouth, such signal remaining visible until the engine has commenced to wind up and then returning automatically to zero.

1874. No. 4215. IRELAND.

Distilling carbonaceous matter, and producing coke and charcoal by means of

modified apparatus of a kind described in the Specification of a Patent granted to J. Imray, on the 14th June, 1872, No. 1795, a communication from T. S. Blair. The material to be treated is fed by double valved hoppers at the top of a vertical retort, and descends therein subject to heat applied externally till it reaches a cooling zone at the bottom, whence it is discharged. A pipe from the top of the retort conveys the inflammable gases and vapours to a gasometer or other receptacle where the vapours are liquefied by condensation. A jet of steam is introduced at the lower part of the retort to extinguish fire in its contents. Iron ores containing oil and carbon treated by this method give off their oils, and have their iron oxide at the same time reduced to metal, so that the mixture of metallic iron with carbonaceous matter discharged from the retort can at once be melted in a furnace for the production of iron or steel.

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